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# INTRODUCTION - IN THE BEGINNING...

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To be effective decision-makers, prospective economists require the development of an extensive toolkit to assess and evaluate choices. This book develops detailed foundational tools to assess and evaluate the costs and benefits associated with public or private decision-making through a cost-benefit analysis (CBA).

Nearly every business and various governing bodies require cost-benefit analysis to ensure the correct decisions are being made with the limited available resources. Whether these decisions relate to investment projects or to wider social policy, it is fundamental that the approach to the evaluation of these choices ensures the optimal outcome.

This book is intended to equip students with the conceptual, analytical, and critical thinking skills needed to undertake a cost-benefit analysis. Through the development of these skills, the reader should be able to evaluate policies and projects in real-world contexts.

Upon completing this book, students should be able to:

1. Construct and interpret a cost-benefit analysis in a variety of real-world situations.
2. Apply non-market valuation methods to correct market failures, including those of a social and/or intangible nature.
3. Evaluate risk and uncertainty in decision-making within a cost-benefit analysis framework.
4. Critically evaluate the ethical and social consequences of decision-making using cost-benefit analysis.

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# PART 1: THE BASICS

Part 1 of the textbook covers the basic conceptual foundations of cost-benefit analysis including:

- (1) Steps in Cost-Benefit Analysis
- (2) Discounting and Decision Rules
- (3) Standing and Perspectives
- (4) Market and Investor Cost-Benefit Analysis





# CHAPTER 1: THE BIG PICTURE

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## Learning Objectives

After completing this chapter, students should be able to:

1. **Define cost-benefit analysis (CBA).**
2. **Describe the purpose of CBA in public and private sector decision-making.**
3. **Identify the underlying economic principles used in CBA.**
4. **Describe how CBA relates to applied welfare economics.**

## What is Cost-Benefit Analysis.

Cost-benefit analysis (CBA) is an activity everyone completes *implicitly* everyday throughout their lives. Whenever you make a decision, people consider the consequences and impacts of their choices by identifying the advantages and disadvantages. When you need to choose between more than one potential alternative, you will choose the option that gives the largest benefit at the smallest cost. So, while you may not have had formal training in cost-benefit analysis, all students undertaking their first CBA course can intuitively understand the framework that we will utilise.

Formal or *explicit* cost-benefit analysis is a systematic tool for identifying, measuring, and comparing benefits and costs from a policy intervention, investment project, program, or government activities. This involves quantifying relevant consequences or impacts in monetary terms. When you conduct a formal *social* cost-benefit analysis you take this concept one step further and quantify all consequences of a policy or project – considering both tangible and intangible impacts. Tangible impacts are those that can be effectively observed and measured. For example, tangible impacts capture the inflows and outflows

of money associated with construction of a road. Intangible impacts cannot be directly observed and measured, such as increased road safety from the road construction.

Consequently, cost-benefit analysis follows a structured decision process – if the social benefits are higher than the social costs then you should accept or undertake the project you are evaluating. This is known as a decision rule.

To evaluate if the social benefit exceeds the social cost, we apply techniques that are similar to those found in financial appraisals. However, the key difference is that cost-benefit analysis does not consider only financial cashflows or transactions attributable to a firm. It considers *all* relevant costs and benefits irrespective of who bears those impacts. Consequently, stakeholders beyond the direct investor in a project or program are considered in a cost-benefit analysis.

Project, program, or policy? These terms are used interchangeably. We use these terms for the evaluation of an investment decision for the private sector and interventions or investments in the public sector.



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# The Purpose of CBA in the Private and Public Sector.

## Private Sector

Using cost-benefit analysis in the private sector provides the framework to formalises the investment process to ensure precise decision-making at the investment level rather than decisions made based on everyday activities. While private firms are driven by profits, cost-benefit analysis allows firms to analyse the wider impacts of an investment decision. In recent times this also involves capturing benefits such as identifying opportunities for commercial profitability through cash inflows (benefits) or evaluating risks to a firm's reputation or branding derived from harmful activities (costs). Therefore, in comparison to financial appraisal in the private sector, a private cost-benefit analysis should capture any external effects that may be harmful or beneficial to a company or firm directly.

## Public Sector

Public sector decision-making can be complex by nature. Views on what policies governments should implement as part of their roles and responsibilities vary widely. Consider childcare policies such as a government subsidy as an example. Those people who have young children may view a childcare subsidy differently to those who have school aged children. Similarly, people without children may view childcare policies as unnecessary. However, we know any changes to childcare policies would have implications for employment, the economy, and provision of other government services due to spending trade-offs.

Consequently, implementing cost-benefit analysis from the perspective of the public sector is complex. As any changes in policies, programs, or projects may have implications on a multitude of stakeholders relevant to a government decision-maker, it is important that these implications are assessed before a policy or project is approved. Particularly for government policy – we can ask clearly '*What are the good and bad effects?*' when evaluating any policy or intervention a government may intend to implement (Sunstein, 2018). Cost-benefit analysis allows decision-makers to move away from political decision-making into a formalised framework that effectively identifies a good decision from a bad decision.

Additionally, CBA has become an established tool used by governments for making social and economic decisions. It provides a framework that allows governments to effectively allocate their scarce resources. CBA also outlines a clear process for prioritization of programs and a transparent framework for consistent decision-making.

### Key Concept – Scarcity

The economic problem of **scarcity** involves unlimited wants and limited resources. When faced with limited resources, choices need to be made. When making choices we face trade-offs. These trade-offs are referred to as opportunity costs.

Remember that economics is the study of how individuals or governments make choices under scarcity. For a refresher on scarcity you may consider reviewing the relevant section this external website: [Understanding Economics and Scarcity | Microeconomics \(lumenlearning.com\)](https://lumenlearning.com/microeconomics/understanding-economics-and-scarcity/)

For cost-benefit analysis in the public sector, we often need to consider:

1. What outcomes are policymakers seeking from the policy or project?
2. What is the role of the government in achieving these outcomes?

The purpose of CBA in the public sector is to ensure resources are allocated efficiently to the competing priorities of the relevant governments. CBA provides a framework for evaluating these implications to ensure an efficient allocation of public sector resources.



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## Social Cost-Benefit Analysis – in Detail.

Regardless of whether we are taking a private or public sector approach to CBA, economists understand the importance of evaluating *all* impacts of a policy, program, or project. By doing so, we are implementing a *social* cost-benefit analysis. Therefore, it is essential to understand that many of the effects caused by a policy, program, or project may be non-monetary in nature. These non-monetary impacts are more likely to be observed in a public CBA where there exists market failure. Market failure is often not considered in private sector CBA. This implies that public sector CBA will naturally be more challenging than private

sector CBA. This is driven by impacts that may not be considered the responsibility of the private sector and therefore fall on the public sector. One good example of this issue is related to externalities.

Consequently, this is how cost-benefit analysis differs from financial appraisal methods. This is highlighted in slideshow below (note: you can use the arrow or click on the rectangles to scroll through the slideshow).



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## Case Study Example – A Ban on Plastic Straws: An Informal CBA Approach

In September 2021, the Queensland State Government implemented a [ban on single use plastics](#).

Many cost-benefit analyses have been conducted on the impacts of plastics on the environment. Negative externalities associated with plastic drinking straws, single use plastic bags and even disposable plastic utensils are extensive, clogging the waterway, oceans, and waste facilities leading to environmental damage and pollution.



Figure 1.1: “Bendy Straws ISO800” by Vox Efx is licensed under [CC BY-ND 2.0](#)

This issue has been in the forefront of the social sphere over the past 10 years. As consumer preferences successfully shifted away from single use plastics bags, all single use plastics were subsequently banned in Queensland. The state government did not take a formal cost-benefit approach to this decision. Instead, the state government likely weighed up implicit costs and benefits in the decision to ban single use plastics and conducted consultation with the general public.

However, as no formal CBA was conducted, there may be costs and benefits that were not considered. For example, glass bottles are much heavier than plastic which can mean the transportation can be more costly. Alternatively, paper bags are biodegradable, and can be made from renewable sources of trees. However, paper bags require more resources in the production compared to plastic bags – and are more difficult to re-use. The impact of increased use of glass or paper bags were not formally evaluated as part of the policy. Consideration of policies to encourage the reuse and appropriate recycling could be potentially more effective, such as container deposit schemes. For more information on the use of deposit schemes to reduce plastic littering, check out [this Conversation article](#).

## Net Social Benefit

As cost-benefit analysis exists as a method of quantifying the decision-making process to ensure an efficient allocation of resources, we require an analytical measure to help quantify the decision-making process.

We calculate the **Net Social Benefit** to identify the increase (or decrease) in the welfare to society that is derived from alternative policies, programs, or projects. For a single period we can define the net social benefit as:

$$(1) \text{ Net Social Benefit} = \text{Total Social Benefit} - \text{Total Social Cost}$$

In this instance we consider the benefits and costs for market and non-market goods related to the project or policy we are evaluating. The total social benefit is the benefit to society from the policy or project including both the private benefits plus any external benefits. If a project has significant external benefits, then the social benefit will be greater than the private benefit. Similarly, the total social cost is the cost to society from the policy or project including both the private costs plus any external costs. If a project has significant external costs, then the social costs will be greater than the private costs. In the absence of market failure, net social benefit will be the same as the net private benefit.

Net social benefit is a simple decision-making tool, however the process of expressing all *social* costs and *social* benefits to calculate the net *social* benefit can be challenging, especially when faced with external impacts that require evaluation.



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### Market Failure

**Market failure** is a situation when resources are used inefficiently usually due to a market distortion. Essentially, a free market fails to achieve an efficient allocation of resources which results in a loss of economic and social welfare.

There are four key types of market failure:

1. Externalities
2. Public goods
3. Incomplete information



#### 4. Uncompetitive market structures

Within the CBA context, the type of market failure is important when identifying social costs and social benefits that need to be accounted for. We will cover various market failure in detail in future chapters.



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## The Economic Concepts that Underpin CBA

There is a clear link between cost-benefit analysis and welfare economics. As mentioned previously, cost-benefit analysis is often used to ensure that resources are allocated efficiently between competing uses. We can use the net social benefit to determine which projects to undertake. If social benefits exceed social costs, then the policy, program, or project improves total social welfare. At the same time, we can use net social benefit to identify allocative efficiency. Allocative efficiency is where resources are utilised in their best use within the economy. Therefore, net social benefit measures *relative* allocative efficiency in a cost-benefit analysis framework.

We can use net social benefit as a measure of allocative efficiency when considering whether a policy or project is worthwhile. Net social benefit identifies the most efficient allocation of resources from our set of available options. Essentially, the largest net social benefit from the options considered in a CBA represents a more allocatively efficient decision (assuming that the projects are mutually exclusive). Therefore, when considering projects that are mutually exclusive – you should undertake the project with the largest net social benefit.

### Key Concept – Mutually Exclusive

In cost-benefit analysis, projects are considered **mutually exclusive** if only one alternative can be selected out of the set of potential options or alternative projects. For example, if a

library is considering replacing its library management system it can choose between Opals, Newgenlib, or Evergreen software. In this case only one management system is required.

Alternatively, projects can be non-mutually exclusive. In this case the decision-maker can choose more than one of the projects under consideration. For example, a local council might consider upgrading a new park and may choose to install new park equipment, planting new trees and a recreational barbecue area. The council could install all three upgrades, or any combination of the three upgrades.

Note: We use the terms options and alternatives interchangeably.

Although we can use the net social benefit to identify a more allocatively efficient outcome, we cannot identify the most efficient allocation of resources i.e., we cannot identify the Pareto efficient outcome. This is because we do not necessarily know the set of *all* possible alternative projects that our scarce resources could be used for. Following this, we can conclude that CBA is a useful tool for identifying *relative* allocative efficiency but cannot be used to identify Pareto efficiency. However, this does not mean that CBA is not useful – we can use CBA techniques to identify relative efficiencies between alternative policies or projects.

If the net social benefit from an intervention is greater than zero it directly implies that there is an increase in the total social welfare for society. Therefore, if the net social benefit is greater than zero, a policy, program, or project should be undertaken as it can be considered a Pareto improvement (as seen in equation (1)). By adopting this approach, we are essentially utilising a *strict* Pareto efficiency rule for project evaluation. This implies that policies are only adopted if they yield positive benefits (Heijman, 1998). However, this does not mean that the distribution of the costs and benefits should be ignored.

When considering a policy or program as a government decision-maker we need to consider the distribution of the benefits and costs used in (1) based on who gains and who loses from a program. We know that society gains when total social benefits are greater than total social costs resulting in a positive net social benefit ( $NSB > 0$ ). Consequently, this condition implies that from a given policy, the winners receive more gains than the losers lose. Hence, if the net social benefit is greater than zero, there is a clear opportunity for those who gain from the implementation of a policy or program to compensate those who lose from the same. This referred to as *a potential for Pareto improvement*.

### Key Concept – Pareto Principles Refresher

Remembering back to first principles, economics is about choice. In the context of CBA, it implies the following:

- (1) Pareto Improvement: where the implementation of a policy or project leads to a strict increase in the net benefits, without anyone being made worse off.
- (2) Potential for Pareto Improvement: the cost-benefit analysis of a project which indicates the capacity to make an unambiguous improvement in welfare by compensating losers so that no-one is worse off after implementation of the project.
- (3) Pareto Efficient (Pareto Optimal): there exists no alternative allocation that can be made to make one person better off without making someone else worse off.

**In the context of CBA, when a project or policy identifies an increase in the Net Social Benefit the project provides an opportunity to reallocate resources to improve the wellbeing of society without making any individual person worse off. Positive net social benefits therefore indicate the potential for a Pareto improvement.**



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## Opportunity Costs

So far, we determined that cost-benefit analysis is clearly linked to allocative efficiency through the evaluation of the net social benefit of a policy, program, or project. At this stage we also revisit the concept of opportunity cost. **Opportunity cost** arises from scarcity – we have unlimited wants or needs and limited resources to satisfy them. Cost-benefit analysis already allows an analyst to assess how we can make best use of our limited resources given a set of potential projects. If we are not using our resources in one project, we would use them in an alternative project. Therefore, there is an opportunity cost in the form of alternative benefits that could have been realized when choosing one alternative project over another.

### Key Concept – Opportunity Cost

The **opportunity cost** is the value of the next best alternative use. In CBA this would be the next best project.

Opportunity cost plays a crucial role in how CBA analysts evaluate impacts, and is a fundamental concept we will leverage off in future chapters.



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## The Status Quo and Incremental Cost-Benefit Analysis

Economics often focuses on comparative analysis.

Often when conducting a CBA, we compare the outcome of the policy or project *with the proposed* change against the outcome that would occur *without the change*. Therefore, we are effectively comparing the current “state of the world” against the proposed use of the resources in the project we are evaluating. The “state of the world” is often referred to as the ***status quo***.<sup>1</sup> This assumes that the resources utilised in the project would be put to their next best alternative use. As economists think at the margin, we are interested in the incremental costs or benefits of each alternative project relative to the status quo. By utilising an incremental analysis, only costs and benefits that would not have occurred in the status quo scenario should be included in the CBA. Alternatively, a policy or project can be compared to a ***base case scenario***. A base case scenario is used when the policy or project must be undertaken in some form implying a change must occur, and incremental costs and benefits would be evaluated against this baseline. Example 1.1 highlights incremental analysis.

### Example 1.1

Assume that a government entity responsible for transport infrastructure would like to review a section of a highway that has observed several serious roadside incidents over the past year. As a CBA analyst you were asked to compare two alternative projects against the current road condition. The two projects are:

- (1) Resurfacing the highway;
- (2) Resurfacing and installing new safety barriers.

The information you collected is outlined in Table 11. The status quo in this instance is the current state of the project.

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1. This is often also referred to as the Current policy, Do nothing, or Business as usual scenarios in various applications and textbooks.

**Table 1.1: Hazard reduction and mitigation project on a state highway.**

	(1) Status Quo	(2) Resurface Highway	(3) Resurfacing and Safety Barrier Installation
<b>Revenues</b>			
Reduced travel time (\$ m)	0	150.5	160.7
<b>Expenditures</b>			
Construction (\$ m)	0	30.4	50.4
Maintenance (\$ m)	15	15	16
<b>Net Social Benefit</b>	<b>-15</b>	<b>105.1</b>	<b>94.3</b>

The status quo in this instance would be to continue maintenance on the highway. The goal is to assess project (2) and (3) relative to the status quo to identify which project should be undertaken using the net social benefit criterion.

As can be seen in Example 1.1, project (2) has the highest net social benefit and should be undertaken in this instance based on the incremental analysis.

## Revision



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## Summary of Learning Objectives

1. Cost-benefit analysis (CBA) is a systematic tool for identifying, measuring, and comparing benefits and costs from a policy intervention, investment project, program, or government activities.
2. CBA is used in the private sector to identify profitable investments. In the public sector, CBA is used to identify the best use of public funds and ensuring the efficient allocation of scarce resources.
3. When undertaking a CBA we calculate *the Net Social Benefit* to identify the increase (or decrease) in the welfare to society that is derived from alternative policies, programs, or projects.
4. CBA leverages off the principle of potential Pareto improvement. When the NSB is positive there is an opportunity to undertake a project due to the compensation principle.

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# CHAPTER A1: CONTEXT MATTERS!

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## Learning Objectives

After completing this chapter, students should be able to:

1. Identify the different CBA types
2. Outline the steps of a CBA

## Types of CBA Analysis

CBA can be used as a tool to assess prospective projects as well as tool to evaluate retrospectively. It is important to know what type of CBA you are conducting to ensure you use suitable technical methods for evaluation and provide appropriate recommendations.

An *ex-ante* cost-benefit analysis is carried out prior to investing in a policy or project. It is a prospective CBA, where you consider the possibilities available. This format of CBA is useful for making decisions about the use of resources in the future. An ex-ante CBA will allow a policymaker to identify if resources should be used on a particular policy or project. When undertaking an ex-ante CBA, you are essentially asking – “Is this policy/project worthwhile?”. The result of an ex-ante cost-benefit analysis is the recommendation for a project to be undertaken or not.

An *ex-post* cost-benefit analysis is conducted at the end of a policy or project. This format of CBA is retrospective and allows the evaluation of the profitability and/or goals of the project. An ex-post CBA will allow for the evaluation of the efficiency of the policy or program in a way that allows you to measure the exact impact caused by the project. When undertaking an ex-post CBA, you are essentially asking – “Was this a good policy/project?”. Ex-post CBA is often used as a learning tool to ensure that future projects can allow for the identification of errors and biases that may have been present in the ex-ante CBA.

A more recent method of CBA, called *in medias res*, allows decision-makers to utilise preliminary data to evaluate the policy or project while it is currently in progress. The idea of this type of CBA is to consider

if the continuation of the policy or project is a good idea. This format of CBA is particularly useful in the public sector as part of the evaluation of policy continuation. An example of an Australian in medias res CBA can be found here:

[An In Medias Res Economic Cost-Benefit Analysis of ACT Container Deposit Scheme](#)



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## Steps in A CBA

In this course, we follow the same steps as outline by the [Australian Government Department of the Prime Minister and Cabinet](#).<sup>1</sup>

1. Specify the options or set of alternatives under consideration.
2. Decide whose benefits and costs count.
3. Identify the impacts and select measurement indicators.
4. Predict the impacts over the life of the proposed project, program, or policy.
5. Monetise all impacts (attach \$ values).
6. Discount future costs and benefits to obtain present values.
7. Compute the net present value (NPV) of each project.
8. Perform a sensitivity analysis.
9. Reach a conclusion.

In addition to the aforementioned steps, when conducting a CBA as a consultant it is imperative to discuss the terms of reference with the stakeholder or client requesting the CBA.

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1. Note that we will return to this in detail in [Chapter 13: Guidelines to CBA Report Writing](#).

## Summary of Learning Objectives

1. There are three types of CBAs – ex-ante (before), ex-post (after) and in medias res (during).
2. There is a clear 9 step framework for developing a CBA identified by the Australian Federal Government.

# CHAPTER 2: DECISIONS, DECISIONS, DECISIONS.

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## Learning Objectives

**After completing this chapter, students should be able to:**

1. Explain why it is necessary to discount in cost-benefit analysis.
2. Implement discounting over single and multiple periods.
3. Calculate the NPV, IRR, and BCR.
4. Utilise decision rules to identify worthwhile projects using NPV, IRR, and BCR methods.

## Introduction

In this chapter we want to be able to identify the net social benefit for any policy, project, or program under consideration in a cost-benefit analysis. Remembering the net social benefit is the welfare derived from the policy, program, or project under consideration, there are three key methods (or criterion) for estimating the Net Social Benefit of a project in CBA:

- (1) Net Present Value,
- (2) the Internal Rate of Return, and
- (3) Benefit-Cost Ratio

We will look at each method consecutively. But first we need to understand key concepts that capture social time preferences within the confines of cost-benefit analysis. Then, we will look at the three methods for finding the net social benefit. We will conclude this chapter with a framework that allows us to compare between project choices. This is particularly important when projects are potentially mutually exclusive.

**Reminder:** we use the terms project, policy, and program interchangeably.

## Time Preferences and Net Social Benefit

As we defined in the first chapter the net social benefit is the difference between the total social benefits and the total social costs:

$$(1) \text{ Net Social Benefit} = \text{Total Social Benefits} - \text{Total Social Costs}$$

Let us consider an example:

Assume a company is interested in purchasing a new software. The initial capital investment of \$10,000 is required to purchase the software. The expected benefit to the company is an increase in productivity of \$25,000. Therefore, we can calculate the net benefit to the company as  $NB = \$25,000 - \$10,000 = \$15,000$ . Since the net benefit to the company is positive, the company should purchase the software. This assumes that the purchase of the software experiences no market failures.<sup>1</sup>

However, we know that benefits and costs of a project may not occur in a single period and therefore the analysis of net social benefit is not static in most cases. Projects, programs, or policies can have short-term impacts or long-term impacts. It is critical to account for the period of time in which the benefits accrue. If we consider the example from before whether the company purchases software, it would be safe to assume that the company would continue to receive benefits from the software into the future and not just once off.

Let us assume the company does not receive a benefit of \$25,000 up front and instead received a benefit of \$25,000 in 5 years. This introduces an element of time into our decision-making process. With this addition of time there is an element of uncertainty. Therefore, the value of a sum of money should be valued differently depending on *when* the cash flow occurred.

If you had the option to receive \$25,000 now or \$25,000 in three years which, would you choose? A rational individual would choose to receive the \$25,000 today as three years is a long time to wait.

---

1. Net benefit is the term used here as there are no social impacts of the investment that need to be accounted for.

## Time Value of Money

The time value of money demonstrates that all things being equal, a dollar today is worth more than a dollar in one year. Even if there is no inflation, a dollar today can be used productively to ensure that it yields a greater value in the future. Therefore, there is an opportunity cost that is associated with the time you wait to receive money.

Consequently, we cannot compare dollar values that accrue or occur at different points in time. Our solution to this problem is compare costs and benefits over time by discounting.



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## Discounting

Following from the implications of the time value of money, a key element of cost-benefit analysis is the evaluation of costs and benefits that occur over time. This evaluation is known as discounting.

**Discounting** is the methods we use to consider the benefit and costs that accrue progressively. Discounting refers to the process of estimating the present value of a future cash flow or monetary values. Traditionally, in CBA we discount all benefits and costs into the present value as it provides a common metric for comparison. This means we express the monetary values received throughout the life of a project at the same point in time.

Discounting is a key element in valuing future benefits and cost within a cost-benefit analysis framework. By discounting the expected value of benefits and costs, we can determine if giving up some consumption benefits today yields greater benefits in the future. Therefore, the need for discounting arises from opportunity costs in CBA.

### Key Concept – Benefit and Cost Streams or Cash Flow?

For the purpose of this course, it is a good idea to view the accrued benefits and costs as “cash flows”. When we refer to cash flows in this book, we are referring to the monetised values of tangible and intangible benefits and costs. Therefore, although we use the term cash flow, the dollar values may not reflect the market prices.

We will use the terms cash flow and benefit/cost streams interchangeably.

## Discount Rate

To be able to calculate the present value of a benefit or cost we need to determine the appropriate discount rate. Often in financial appraisals the choice of discount rate is the prevailing interest rate for investors, as it captures the opportunity cost of investing. However, in a cost-benefit analysis, the discount rate represents more than an interest rate. The discount rate should capture the preferences for consumption, social time preferences, and relevant opportunity costs. Therefore, the discount rate used in cost-benefit analysis should be higher than the interest rate used in financial appraisals. Consequently, we refer to the discount rate used in social cost-benefit analysis as the “social discount rate”.

It is also important to note that there is no one single discount rate that is used for all projects in social cost-benefit analysis. This is due to different policies having different opportunity costs.

### Key Concept – No single social discount rate

The discount rate is often different depending on the type of projects being evaluated. For example, the choice of social discount rate for evaluation of climate change mitigation policies would be significantly different to those social discount rates used in transportation infrastructure.

It is of utmost importance to ensure you select the appropriate discount rate for estimating present or future values. The choice of discount rate can make a significant difference to whether the project is positive or negative. It also impacts the relative desirability of projects when costs and benefits accrue at different times or over different project lives.

So, by discounting using the social discount rate we can compare the costs and benefits at different points in time within a common metric, either in the present or future.



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## Present Value

As we now understand the components required for discounting, we can implement the present value formula to calculate the present discounted value of benefits and costs. The present value is the value of a stream of benefits or costs at the date of evaluation in the project i.e., the current year.

For a single period the present value formula is:

$$(2) \quad PV = \frac{FV}{(1 + dr)}$$

where  $PV$  is the present value,  $FV$  is the future value of the benefit or cost stream and  $dr$  is the social discount rate.

### Example 2.1:

Assume we have a future benefit stream of \$10,027.50 in a year's time (year 1) and a social discount rate of 5%. We can calculate the present value of the benefit in present terms (in year 0) as follows:

$$\begin{aligned} PV &= \frac{\$10,027.50}{(1 + 0.05)} \\ &= \$9,550 \end{aligned}$$

When comparing between mutually exclusive projects we would select the project with the largest present value.

Click through the slideshow below to see the steps involved in calculating the present value from Example 2.1.



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## Future Value

As we are interested in expressing the cash flows in a common metric, an alternative method is to calculate the future value. This process is also known as **compounding**. A future value is the value of a current benefit or cost stream at some date in the future. To calculate the future value, we can rearrange the formula we had for the present value:

$$(3) \quad FV = PV \times (1 + dr)$$

### Example 2.2

Assume we have a current cost stream of \$9,000 (at year 0). We would like to calculate the future value of that \$9,000 cost in a year's time (end of year 1) using a social discount rate of 5%. Substituting in the values will give:

$$\begin{aligned}
 FV &= \$9,000(1 + 0.05) \\
 &= \$9450
 \end{aligned}$$

Therefore, the future value tells us how much the benefit or cost stream observed today would be worth in the future.

Click through the slideshow below to see the steps involved in calculating the future value from Example [2.2](#).



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## Multiple Period Discounting & Compounding

In the above examples we assume a single period for discounting and compounding. However, we know that benefits and costs accrue over long periods of times. We can extend our formulas for calculating the present value and the future value fairly easily.

Assume there is a benefit stream of \$15,000 that is realised after 5 years, and the social discount rate is 5%.

We can use our present value formula to move our benefit back in time from Year 5 to Year 4.

$$\begin{aligned}
 PV_{year4} &= \frac{FV}{(1 + dr)} \\
 PV_{year4} &= \frac{\$15,000}{(1 + 0.05)} \\
 &= \$14285.71
 \end{aligned}$$

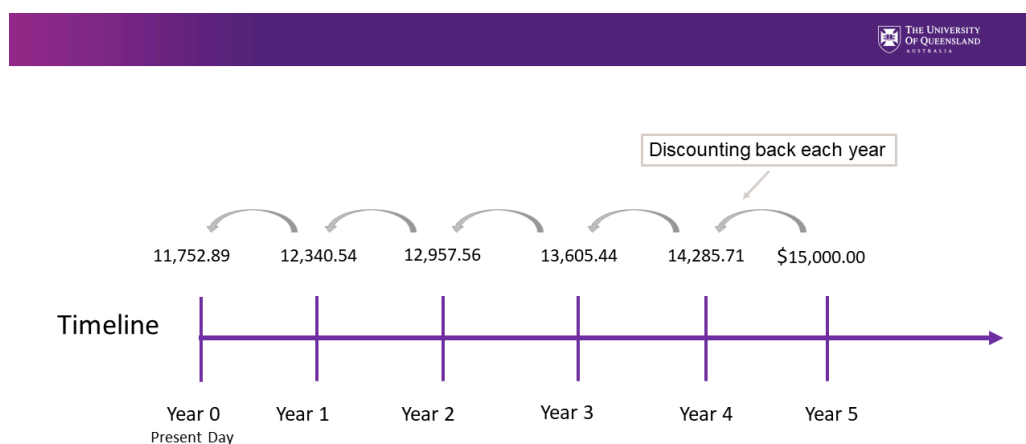
Therefore we have moved the value of the benefit stream to an equivalent value for Year 4. We can do the same thing to move the Year 4 value to Year 3.

$$\begin{aligned}
 PV_{year3} &= \frac{FV}{(1 + dr)} \\
 PV_{year3} &= \frac{\$14285.71}{(1 + 0.05)} \\
 &= \$13605.44
 \end{aligned}$$

Continuing this process to move towards the present value at Year 0, you would get the results in the Table [2.1](#) (and illustrated in Figure [2.1](#))

**Table 2.1: Representation of How to Apply the Single Period Present Value Formula to Multiple Periods :**

Year	Substitution	Value in Relevant Year
Year 5		15,000
Year 4	$PV_4 = FV/(1 + dr)$ $= 15,000/(1 + 0.05)$	=14,285.71
Year 3	$PV_3 = 14,285.71/(1+0.05)$ Which is the same as: $PV_3 = PV_4/(1 + 0.05)$ $= [15,000/(1 + 0.05)]/(1 + 0.05)$ $= 15,000/(1 + 0.05)^2$	=13,605.44
Year 2	$PV_2 = 13,605.44/(1+0.05)$ Which is the same as: $PV_2 = PV_3/(1 + 0.05)$ $= [15,000/(1 + 0.05)^2]/(1 + 0.05)$ $= 15,000/(1 + 0.05)^3$	=12,957.56
Year 1	$PV_1 = 12,957.56/(1+0.05)$ Which is the same as: $PV_1 = PV_2/(1 + 0.05)$ $= [15,000/(1 + 0.05)^3]/(1 + 0.05)$ $= 15,000/(1 + 0.05)^4$	=12,340.54
Year 0 (Present day)	$PV_0 = 12,340.54/(1+0.05)$ Which is the same as: $PV_0 = PV_1/(1 + 0.05)$ $= [15,000/(1 + 0.05)^4]/(1 + 0.05)$ $= 15,000/(1 + 0.05)^5$	=11,752.89

Figure 2.1:  
Discounting  
\$15,000 received  
in 5 year to the  
present

From Table 2.1 above we can see that calculating a multi-period present value is an iterative process. The derived formula for discounting can therefore be written as:

$$(4) \quad PV = \frac{FV}{(1 + dr)^t}$$

where  $t$  is the number of years before the benefit or cost is realised and  $\frac{1}{(1+dr)^t}$  is known as the discount factor.

To confirm this result, we can apply the formula to our example above where  $t = 5$  years:

$$\begin{aligned} PV &= \frac{\$15,000}{(1 + 0.05)^5} \\ &= \$11,752.89 \end{aligned}$$

In CBA we mostly deal with present values for our analysis. However, we may also need to compute the future value. To find the future value over multiple periods, we can rearrange the result from (4) to get the following formula:

$$(5) \quad FV = PV \times (1 + dr)^t$$

Future value often used to account for growth or inflation by replacing the discount rate ( $dr$ ) with the relevant growth or inflation rate. These future values are then usually discounted back into the present value.



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## Conventions for Benefit and Costs Streams

The initial or present period is always referred to as year 0. Year 1 is one year from the present year. Unless otherwise stated we assume that benefits or costs accrue on the last day of the year. However, we can also

conduct mid-year and beginning of year discounting by adjusting the formula. A discussion of mid-year and beginning of year discounting can be found in [Chapter 3](#).

## Key Methods for Estimating Net Social Benefit

There are three key methods for estimating the Net Social Benefit of a policy, program, or project. Each method requires all social costs and benefits to be accounted for in the application of the formula. If benefits and costs are not correctly identified, predicted, and monetised, this can potentially lead to the incorrect conclusion relating to the project.

### Net Present Value

Now we understand present value and future value, we can use this information to calculate the net present value. The **Net Present Value (NPV)** is useful for dealing with multiple time periods and numerous benefits and costs may be involved in a policy, program or project. In its simplest form the net present value is:

$$(6) \quad NPV = PV(Benefits) - PV(Costs)$$

A useful expression for computing the net present value over multiple time periods is:

$$(7) \quad NPV = \sum_{t=0}^t \frac{Benefits}{(1 + dr)^t} - \sum_{t=0}^t \frac{Costs}{(1 + dr)^t}$$

Or alternatively if *Net Social Benefit (NB)* = *Benefits* – *Costs* in each given year:

$$(8) \quad NPV = NB_0 + \sum_{t=1}^t \frac{NB}{(1 + dr)^t}$$

where you take the difference between the benefits and the costs in each period.

### Example 2.3

Suppose a project under consideration has an initial investment cost of \$1,000. The project is expected to yield a benefit stream of \$300 per year for 5 years and has an ongoing cost of \$50 per year for the life of the project. This information is summarised in Table 2.2 below.

If we apply the first method of calculating the net present value based on equation (7) we start

by calculating the present value of each benefit stream in column (4). Then we calculate the present value of the cost stream per column (5). Then you take the total sum of the present value of the benefits and subtract the total sum of the present value of the costs. The difference is the NPV of the project valued at \$53.09.

Alternatively, per equation (8) the NPV can be found by taking the difference between the benefits and the costs to find the net benefit shown in column (6). After this step you calculate the present value of each net benefit in a given year, summing them up will give the net present value of \$53.09. Note that both methods result in the same answer. However, the second method using the net benefits is more commonly used in spreadsheet applications.

**Table 2.2: Calculating the Net Present Value using a 6% Discount Rate**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Year	Benefit	Initial Costs	Ongoing Cost	PV Benefits	PV Costs	Net Benefit (NB)	Present Value of NB
0		\$1,000.00			\$1,000.00	-\$1,000.00	-\$1,000.00
1	\$300.00		\$50.00	\$283.02	\$47.17	\$250.00	\$235.85
2	\$300.00		\$50.00	\$267.00	\$44.50	\$250.00	\$222.50
3	\$300.00		\$50.00	\$251.89	\$41.98	\$250.00	\$209.90
4	\$300.00		\$50.00	\$237.63	\$39.60	\$250.00	\$198.02
5	\$300.00		\$50.00	\$224.18	\$37.36	\$250.00	\$186.81
<b>Total</b>				\$1,263.71	\$1,210.62		
<b>Net Present Value (at 6%) =</b>							<b>\$53.09</b>

## Finding the NPV using Excel

To make our lives easier, we can use Excel to calculate the NPV of a project using the =NPV() function. The =NPV() function will calculate the net present value of future benefits and/or costs from year 1 onwards. Any costs or benefits accrued in the present year (year 0) should not be captured in the function.

The NPV function can be used in consecutive row or columns as illustrated in Example 2.4 below.



## Example 2.4

Consider project Y which has an initial cost of \$800 and a yearly benefit of \$300, summarised in Table 2.3:

**Table 2.3: Benefits and Costs of Project Y**

Year	Net Benefit
0	-800
1	300
2	300
3	300

Assuming the appropriate discount rate is 6%, we can implement the NPV function using the `=NPV()` command as illustrated in Figures 2.2 and 2.3 below. i.e., `=NPV(discount rate, series of benefits/costs that require discounting)`.

1										
2	Year	0	1	2	3		Discount Rate	6%		
3	Net Benefit	-800	300	300	300		NPV	=NPV(I2,D3:F3)+C3		
4										
5										
6										

Figure 2.2:  
Calculating the  
NPV using Excel  
(rows)

1						
2	Year	Net Benefit				
3	0	-800		Discount Rate	6%	
4	1	300				
5	2	300		NPV	=NPV(F3,C4:C6)+C3	
6	3	300				
7						

Figure 2.3:  
Calculating the  
NPV using Excel  
(column)

Note that the discount rate is highlighted first, followed by the cashflows from year 1 onwards. Cashflows from year 0 need to be either added or subtracted depending on whether it is a cost or a benefit. In this case we have a cost in Year 0 in the Excel spreadsheet inputted as -800 and therefore, to subtract it from the present value of the cashflows (highlighted in red) we will need to add it back (i.e., a positive number plus a negative number gives a negative number).

The result is an NPV = \$1.91.

To replicate this example you can download the spreadsheet found here: [Example2\\_4](#)



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## Net Present Value Decision Rule

Based on our definitions for allocative efficiency outlined in [Chapter 1](#), we should undertake any project where the  $NPV > 0$  as there is a potential for pareto improvement. We refer to this as the NPV criterion. However, the decision rule for determining the highest net social benefit using the NPV **decision rule** is not that simple.

### Key Concept: Decision Rules

A **decision rule** outlines the scenarios where we would accept or reject a project, program, or policy we are evaluating within our cost-benefit analysis framework.<sup>2</sup>

We have three possible scenarios for which we need to identify the NPV decision rule:

1. Considering *one* project in comparison to the status quo.

When a single project is compared to the status quo, the decision rule is simple. If the  $NPV > 0$  *the project should be undertaken* as the net social benefit is greater than zero and the evaluation framework has identified a potential for pareto improvement as the present value of the discounted benefits exceeds the present value of the discounted costs. If the  $NPV < 0$  *reject the project in favour of the status quo*. A NPV less than zero would indicate that the project is detrimental to society and has a negative impact overall.

---

2. Similar to how a decision rule is formulated in your introductory statistics course. The decision rule identifies the circumstances where you reject or do not reject the null hypothesis under investigation. However, in the instance of decision rules in CBA we are creating a clearly defined rule where we reject or do not reject the project under consideration relative to the status quo or base case scenario.



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## 2. Considering multiple projects that are *mutually exclusive*.

If you are completing a cost-benefit analysis on a series of mutually exclusive projects, *the project with the highest NPV should be selected*. The project with the highest NPV is considered the most allocatively efficient outcome from the set of potential projects. However, if the  $NPV < 0$  for all alternative projects, reject the projects in favour of the status quo.

### Key Concept – Logic of the NPV decision rule

The NPV identifies the monetised net benefit as an equivalent of today's cash. Consequently, when comparing NPVs, we select the alternative with the highest NPV.

## 3. Considering multiple projects that are *not* mutually exclusive.

When comparing projects that are not mutually exclusive, decision rules can become more complex. We can see this illustrated in Table 2.4 below. If there were no budgetary constraints, we would undertake all projects with a positive NPV. This would be projects A, B, D and E. Following our NPV criterion, we would not undertake project C as it is not a valuable use of our resources as it has a negative NPV.

However, in the real world we are often limited by a budget constraint sometimes referred to as capital rationing. In this instance it is best to take a capital budgeting approach to the cost-benefit analysis decision. In the instances where there is a budget, Stokey and Zeckhauser (1978) suggests that projects should be ranked by the ratio of *net benefit to capital cost*. This is the same as calculating the ratio of *net present value to capital cost* when net present value is our method of choice to approximate net benefits. Note that this method is different to calculating the benefit-cost ratio as it utilises the initial capital investment in the project rather than all associated costs. Once ranked, analysis should undertake projects in ranked order until budget exhausted. This is under the assumption that projects are indivisible in the context of social cost-benefit analysis.

However, the best approach from an *economic perspective* should utilise the NPV as it represents the best allocation of resources to society. The result is heavily influenced by the available budget. For example:

- Budget = \$900 – undertake projects A and B which would expend the full budget and receive the highest *total* net present value.
- Budget = \$1,000 – undertake projects A, B and E which would expend the full budget and receive the highest *total* net present value.
- Budget = \$500 – project B should be selected over project A and E combined as it would provide the largest net present value.

**Table 2.4: Ranking Projects and Budgetary Constraints.**

Project	PV Capital Cost	PV Ongoing Cost	PV Benefits	Net Benefit (NPV)	NB/PV(Capital Cost)	Rank
A	400	50	1000	550	1.38	1
B	500	25	1200	675	1.35	2
C	300	30	200	-130	-0.43	5
D	150	10	300	140	0.93	3
E	100	10	125	15	0.15	4

## Net Present Value and the Choice of Discount Rate

Selecting the correct discount rate is critical for the decision rule. The choice of discount rate will determine whether a project is accepted or rejected. As the discount rate increases, the net present value decreases.

Typically, when considering social cost-benefit analysis, a policy or program involves a large upfront cost followed by benefits accruing at a later date. When benefits accrue later in a project – the lower the discount rate the more attractive the project will be as the net present value will be much higher. If we select a higher discount rate than necessary, a desirable project may be rejected. Alternatively, if the selected discount rate is too low this may result in an undesirable policy or project may be accepted. See Example 2.5 below.

### Example 2.5

Suppose we are considering two mutually exclusive projects A and B with the stream of net benefits summarised in Table 2.5. The projects have the same initial investment cost of \$15,000. The difference between the projects is the size of the benefits over time. The benefits of project A decrease over time and the benefits of project B increase over time.

**Table 2.5: Comparison Over Time for Two Projects**

Year	Project A	Project B
0	-15,000	-15,000
1	6000	1500
2	5000	2500
3	4000	3500
4	3000	4500
5	2000	5500
6	1000	6500

From our NPV equation identified in (7), we know there is a negative relationship between the net present value and the discount rate. This is illustrated by a downward sloping curve in Figure 2.4.



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*Figure 2.4: NPV Curves for Projects A and B*

If we assume the appropriate discount rate is 5% for the project, we would choose project B over project A as NPV B (\$4,581.53) > NPV A (\$3,486.16). Alternatively, our decision rule would indicate the project A should be accepted over project B if appropriate discount rate was 12%. This change in preferences can be confirmed when we plot the NPV curves for project A and project B on the same graph in Figure 2.4.

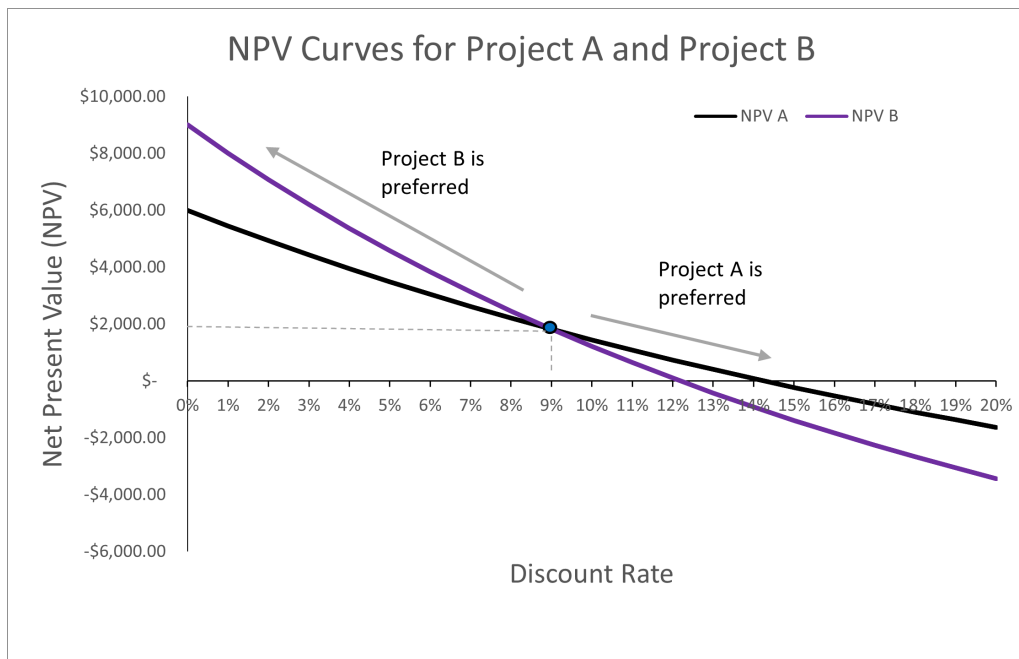


Figure 2.5: NPV Curves for Project Comparison and Crossover Rate

As highlighted in Figure 2.5, when we plot both project A and project B on the same graph we can see that project B is preferred to project A at all discount rates between zero and 9%. Once the discount rate is above 9%, we should choose project A over project B. This illustrates how the timing of benefits interacts with the discount rate. When the discount rate is sufficiently high, the preferred project will be the project with the larger cashflows upfront. More specifically, we see in Figure 2.5 the point where the preferences for which mutually exclusive project we would accept switches. This is known as the crossover rate or switching rate. At this point the NPV of project A and Project B are equal, and we are indifferent between the two projects. As illustrated in the figure, this occurs at 9%.

We know that Project B has a steeper NPV profile. This suggests that Project B is more sensitive to changes in the discount rate compared to Project A. Remembering that the benefits of Project A decrease over time and the benefits of Project B increase over time – we can see that discount rates above the switching point result in preferencing Project A. This is due to inverse relationship between the NPV and the discount rate. The higher the discount rate the lower the present value of future net benefits. Therefore, if the discount rate is high project A is preferred as the net benefits are accrued earlier in the project relative to the net benefits accrued to Project B which occur later in the project. Therefore, we can see that in this case a high discount rate indicates a preference for larger cash flows up front.

## Advantages of the NPV Decision Rule over other Decision Rules

The advantage of the NPV decision rule is the clear monetisation of the costs and benefits in today's monetary terms. It provides a practical measure of the magnitude of the net benefits as a monetary value. Further to this, the NPV decision rule provides a clear decision criterion for comparison.

## Limitations of the NPV Decision Rule

The main limitation of the decision rule is it relies on the selection of the appropriate discount rate. It is possible that a change in the discount rate may lead to a change in the decision rule. Consequently, CBA analysts often look at the sensitivity of the NPV to a series of discount rates. This is known as a sensitivity analysis and will be covered in depth in [Chapter 10](#).

## The Internal Rate of Return

An alternative to the NPV approach is to calculate the internal rate of return (IRR) for policy, project, or program. The **internal rate of return** is discount rate in which the NPV is zero. This implies that the IRR is the discount rate where the sum of the discounted benefits is equal to the sum of the discounted costs. i.e.,

$$(9) \quad \sum_{t=0}^t \frac{Benefits}{(1 + dr)^t} = \sum_{t=0}^t \frac{Costs}{(1 + dr)^t} = 0$$

This can also be expressed as:

$$NPV = -Cost_0 + \frac{NB_1}{(1 + dr)} + \frac{NB_2}{(1 + dr)^2} + \frac{NB_3}{(1 + dr)^3} + \dots + \frac{NB_t}{(1 + dr)^t} = 0$$

$$(10) \quad NPV = \sum_{t=0}^t \frac{NB_t}{(1 + IRR)^t} = 0$$

We can effectively find the IRR in two ways:

- 1) Graphically
- 2) Using the =IRR() function in Excel

### Finding the IRR graphically:

As mentioned before, the IRR is the point where the NPV is zero. This can easily be identified on the relevant NPV curve by looking at where the curve intersects the horizontal axis (i.e., where NPV = 0 on the vertical axis, shown in [Figure 2.6](#)). However, this method only provides an approximation of the IRR.

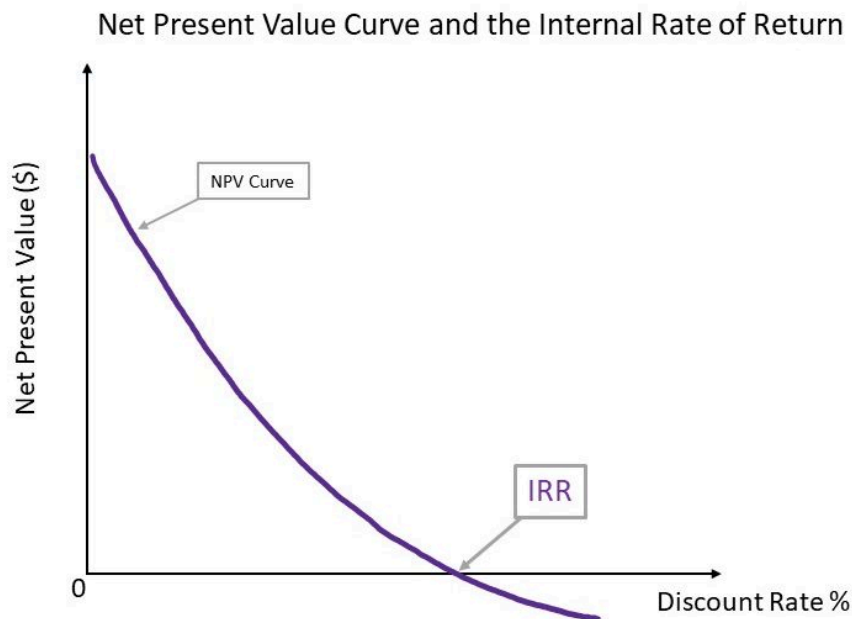


Figure 2.6: The NPV Curve and The Internal Rate of Return

### Finding the IRR using Excel:

Using the “=IRR()” function in Excel and highlighting the cashflow series from time zero onwards will provide the IRR.

#### Example 2.6

Following from Example [2.5](#) replicated below:



**Table 2.6: Net Benefits of Two Projects**

Year	Project A	Project B
0	-15,000	-15,000
1	6000	1500
2	5000	2500
3	4000	3500
4	3000	4500
5	2000	5500
6	1000	6500

Calculating the NPV's across a range of discount rates and then plotting in a graph will allow us to identify the IRR for Project A and Project B respectively. This identifies the NPV profile of each project.

**Table 2.7: Present Value of Net Benefits for Two Projects**

Discount Rate	NPV A	NPV B
0%	\$ 6,000.00	\$ 9,000.00
1%	\$ 5,452.35	\$ 8,013.72
2%	\$ 4,928.46	\$ 7,082.28
3%	\$ 4,426.95	\$ 6,201.98
4%	\$ 3,946.58	\$ 5,369.45
5%	\$ 3,486.16	\$ 4,581.53
6%	\$ 3,044.59	\$ 3,835.34
7%	\$ 2,620.86	\$ 3,128.19
8%	\$ 2,214.00	\$ 2,457.59
9%	\$ 1,823.13	\$ 1,821.26
10%	\$ 1,447.39	\$ 1,217.06
11%	\$ 1,086.02	\$ 643.01
12%	\$ 738.27	\$ <b>97.28</b>
13%	\$ 403.46	-\$ 421.84
14%	\$ <b>80.95</b>	-\$ 915.94
15%	-\$ 229.88	-\$ 1,386.50
16%	-\$ 529.60	-\$ 1,834.88
17%	-\$ 818.73	-\$ 2,262.38
18%	-\$ 1,097.79	-\$ 2,670.19
19%	-\$ 1,367.25	-\$ 3,059.42
20%	-\$ 1,627.55	-\$ 3,431.12

**Finding the IRR graphically:**

Using the information above, the NPV curve of project A intersects the horizontal axis at approximately 14%. Therefore, the IRR for project A is approximately 14% as this is where the NPV is equal to zero (measured by the y axis). Similarly, the IRR for project B is approximately 12% as shown in Figure [2.7](#).

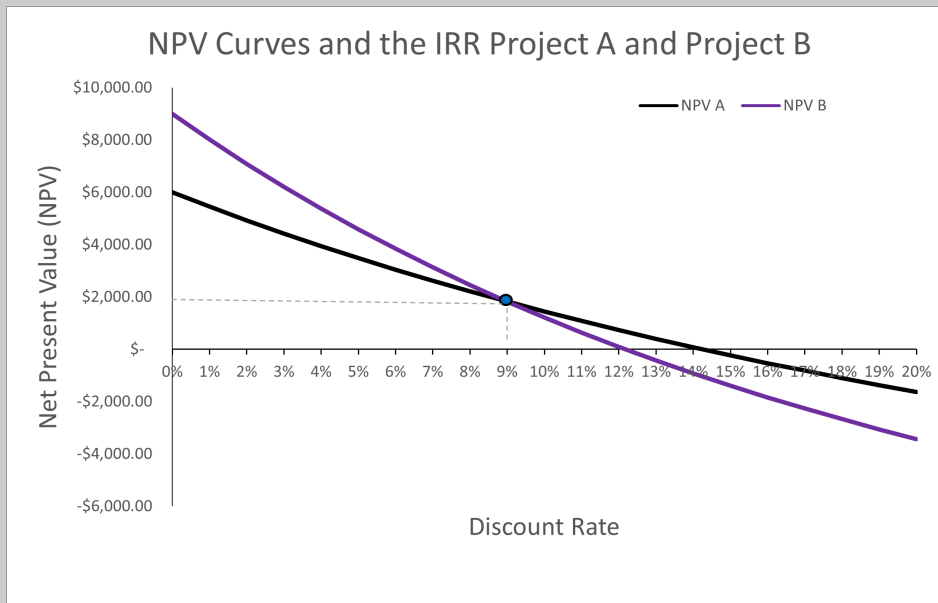


Figure 2.7:  
Graphically  
Finding the IRR

**Finding the IRR using Excel:** Inputting the data into Excel allows us to calculate the IRR by using the “=IRR()” function, illustrated in Figure 2.8.

	A	B	C
1	Year	Project A	Project B
2	0	-15,000	-15,000
3	1	6000	1500
4	2	5000	2500
5	3	4000	3500
6	4	3000	4500
7	5	2000	5500
8	6	1000	6500
9		=IRR(B2:B8)	
10			

Figure 2.8:  
Calculating the  
Internal Rate of  
Return using Excel

By using the “=IRR()” function we can confirm the IRR for project A and project B as 14.3% and 12.2% respectively – see if you can replicate these IRR solutions by downloading the file here: [Example 2.5 & 2.6 data](#).



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## The Internal Rate of Return Decision Rule

As the internal rate of return occurs when the net present value is equal to zero, we can conclude that the IRR represents the highest rate of interest (cost of capital) an investor could afford to pay without losing money on a project if all funds were borrowed and the loan (principal and interest) were repaid (Bierman and Smidt, 2012). The IRR is therefore essentially a break even point for an investment after accounting for interest.

Consequently, once we know the IRR for a project, we can compare this IRR directly with the cost of borrowing at the prevailing market interest rate to finance the project, policy, or program. If we denote the cost of borrowing as  $r$ , the decision rule is:

- Accept the project if  $IRR > r$
- Reject the project if  $IRR < r$

The reason for this decision rule lies in the fact that companies, firms, and governments can often borrow at a lower interest rate to undertake the project and thereby experience the higher rate of return. Essentially, when calculating the internal rate of return we are effectively finding the annualised effective compounded rate of return. Therefore, in essence the IRR is capturing the opportunity for a profitable investment in a project, policy, or program.

### Example 2.7

Suppose you calculated the IRR of the following project. Note: you can replicate this IRR result in Excel.

Table 2.8: Net Benefits for Project X

Year	0	1	2	3	4	IRR
Project X	-5,000	-1500	2000	3000	4000	11.6%

- If the cost of borrowing to finance this project was 10% – the project should be accepted as  $IRR (11.6\%) > r (10\%)$ .
- If the cost of borrowing was 12% – the project should be rejected as the  $IRR (11.6\%) < r (12\%)$ .

At this stage it is important to note that the IRR method will result in the same decision rule as the NPV method when we assume: (1) the projects are *not mutually exclusive*, and (2) there are *no budgetary constraints* that need to be considered. Under these conditions we would accept all projects where the  $IRR > r$ .

For mutually exclusive projects, we should prioritise the project with the highest NPV. The reason for this is illustrated in the section on [IRR limitations](#).<sup>3</sup>

## The IRR and Hurdle Rates

A secondary decision rule may also be part of the acceptability of the project. Specifically, if the project investor has a required **hurdle rate** of return ( $k$ ), the project should be accepted if the  $IRR > k$  and rejected if  $IRR < k$ . This method is more appropriate when considering the CBA from an investor or private perspective where there is a company investing in the project, this is in comparison to the social cost-benefit analysis perspective we assume in this course.

### Key Concept – Hurdle Rate

**A Hurdle rate** is the minimum rate that a company expects to earn when investing in a

3. If we selected the project with the highest IRR we can accidentally select a project with a lower NPV. This is a problem when projects are mutually exclusive as we should always choose the project with the highest NPV when projects are mutually exclusive to ensure we achieve allocative efficiency.

project. The hurdle rate is also often referred to as the company's required rate of return, target rate, or minimum acceptable rate of return (MARR).

## Example 2.8

Following from Example 2.7 above:

**Table 2.9: Project X's IRR**

Year	0	1	2	3	4	IRR
<b>Project X</b>	-5,000	-1500	2000	3000	4000	<b>11.6%</b>

If the company investing in this project requires all projects to have a minimum rate of return of 12.5% we would reject the project under the hurdle requirement as 11.6% < 12% required return for the company.

## The Crossover Rate

One of the benefits of using the IRR to compare projects is it allows us to identify the exact crossover rate (also known as the switching rate). The crossover rate allows us to determine which project is preferred at various discount rates. *It can be useful for comparing mutually exclusive projects at various discount rates.* By taking the difference between the cashflows we can identify the discount rate where the preference between our projects switches using the incremental IRR.

## Example 2.9

Again returning to Example 2.5. By taking the incremental difference between the net benefits of project A and project B and then calculating the incremental IRR on the difference we find the crossover rate of 9%. If project A and project B are mutually exclusive, project B is preferred to project A when the discount rate is less than 9%. For a discount rate above 9%, project A is preferred. At exactly 9%, we are indifferent between project A and project B.<sup>4</sup>

**Table 2.10: Taking the Difference in Net Benefits to Find the Crossover Rate**

Year	Project A	Project B	Difference (A) – (B)
0	-15,000	-15,000	0
1	6000	1500	4,500
2	5000	2500	2,500
3	4000	3500	500
4	3000	4500	-1,500
5	2000	5500	-3,500
6	1000	6500	-5,500
<b>IRR</b>	<b>14.26%</b>	<b>12.18%</b>	<b>9.0%</b>

This result can also be identified in the graph as shown above in Figure 2.7 at the switching point.

## Advantages of the IRR decision Rule

There are two clear advantages of using the IRR decision rule. Firstly, the IRR calculation does not rely on the selection of a discount rate. Secondly, for decision-makers the IRR is an easily understood criteria for decision-making providing an effective way to communicate the results to managers and professionals more broadly.

4. Note that the NPV A is approximately \$2 higher than NPV B at 9%. Consequently, at 9% we should select project A.

## Limitations of IRR

There are quite a few limitations to using the internal rate of return decision rule as the core decision rule when evaluating policies, programs, or projects.

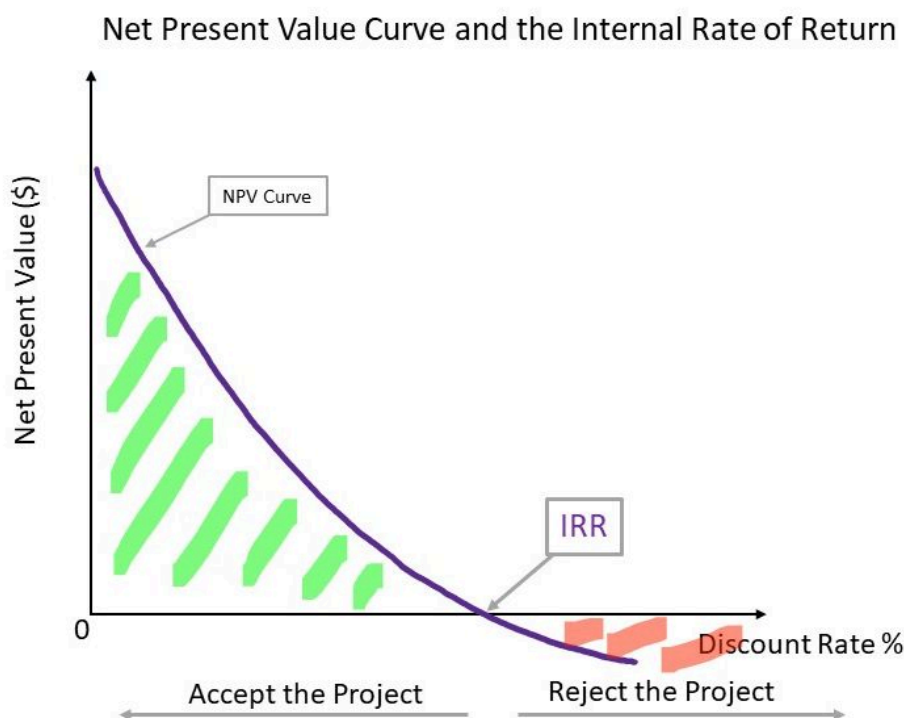
### IRR Comparison to the Status Quo

Using the IRR as a measure of the net social benefit is only considered appropriate if there is only one alternative project that is being compared to the status quo or the projects are not mutually exclusive. In this instance where we are comparing a single policy or project to the status quo, the result from the IRR decision rule will be the same as the NPV decision rule. Specifically:

- If the IRR is greater than the discount rate  $dr$  ( $IRR > dr$ ), then it follows that the NPV would be greater than zero at the same discount rate ( $NPV > 0$  at  $dr$ ) – therefore both the IRR decision rule and the NPV decision rule would lead you to accept the project.
- If the IRR is less than the discount rate  $dr$  ( $IRR < dr$ ), then it follows that the NPV would be less than zero at the same discount rate ( $NPV < 0$  at  $dr$ ) – therefore both the IRR decision rule and the NPV decision rule would lead you to reject the project.

This can be seen clearly in our NPV curve Figure [2.9](#).

Figure 2.9: IRR Decision Rule



However as mentioned above when we discussed [hurdle rates](#), the IRR can be used as a threshold



requirement for private CBAs i.e., an investment project should be undertaken if the IRR is greater than a required rate of return, usually set as a company or department standard rate of return. In these instances where a hurdle rate is required using the IRR decision rule may not result in the same conclusion as the NPV decision rule.

## Multiple IRRs and No IRRs

One significant limitation of using the internal rate of return to drive the decision to accept or reject a project is caused by the potential for multiple or indeterminant IRRs. This often occurs when there is a stream of unconventional cash flows or net benefits. An unconventional net benefit stream is when there is a series of inflows and outflows that change the sign of the net benefit more than once. This usually occurs when the stream of net benefits follows an unconventional format due to high future costs. This is in comparison to a conventional net benefit stream where the sign changes only once (i.e., an initial cost, followed by a series of positive net benefits).<sup>5</sup>

If one of future net benefit streams of a project changes sign, there will be multiple internal rates of return. For example, if the net benefit of a conventional stream follows a  $- , + , - , +$  format, the switching of the sign creates an unconventional net benefit stream.

### Example 2.10

Consider a project with the following net benefits:

**Table 2.11: Unconventional Benefit Streams**

Year	0	1	2
Net Benefit	-200	460	-264

As seen from the table above, the net benefit is unconventional following a  $- , + , -$  format where we observe later benefit streams experience a sign switch in comparison to the conventional  $- , + , +$  format.

5. Projects, programs, or policies with unconventional cashflows have other issues that may affect their attractiveness.

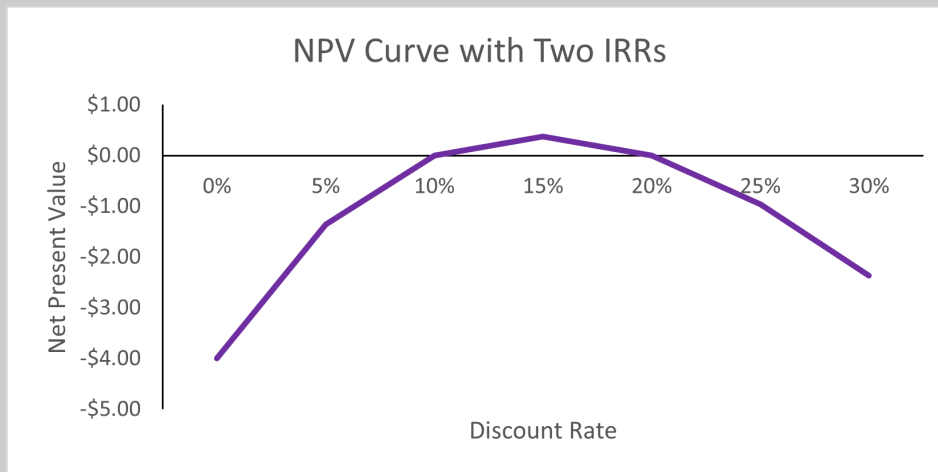


Figure 2.10: NPV Curve with Two Internal Rates of Return

When plotting the NPV curve for this project, we can see that the curve intersects the x-axis twice indicating that there are two points on the curve where the NPV is zero at 10% and 20%. See if you can replicate this NPV curve by downloading this file: [Example 2.10](#)

As seen in Example 2.10, it is possible to have more than one internal rate of return which results in difficulties in identifying the correct internal rate of return for a project. There can also be situations where there is no internal rate of return. This occurs when there is no change in the sign of the net benefit stream – and therefore there is no discount rate that would produce a NPV of zero. This occurs often in healthcare projects which often only run at a cost to a government. The NPV curve of such a project would look similar to Figure 2.11.

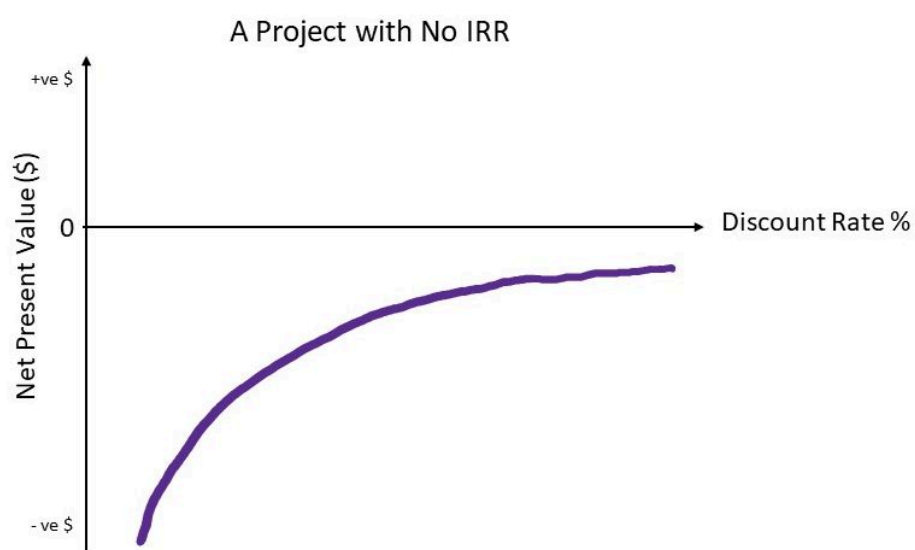


Figure 2.11: An Example NPV Curve for a Project with No IRR

## IRR and the Scale of a Policy or Project

The IRR also does not necessarily consider the scale or the size of the project under consideration.

### Example 2.11

If we have two projects that are mutually exclusive. Project A has an initial cost of \$200 and project B has a cost of \$10. If the life of the projects is two years and the benefits are summarised in Table 2.12. The IRR can be calculated as:

**Table 2.12: Comparison of Project Scale and the IRR**

Year	0	1	2	IRR	NPV @ 5% DR
<b>NPV A</b>	-200	120	120	13%	<b>\$ 23.13</b>
<b>NPV B</b>	-10	7	7	<b>26%</b>	\$ 3.02

In this instance if we made a decision to accept the highest IRR project, we would potentially select the project with a smaller net present value. For example, if the appropriate discount rate is 5% using the IRR decision rule, we would select project B. However, project A clearly has a higher NPV and should be selected over project B.

## NPV vs IRR Decision Rule

As a consequence of the limitations of the IRR, it is clear that we should give preference to the NPV decision rule when comparing multiple projects in the case where the projects are mutually exclusive. This is because the NPV will lead to the maximisation of net benefits. The NPV rule will lead to a clearer evaluation on which project provides the largest net benefit – thereby achieving allocative efficiency.



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## Benefit-Cost Ratio

The final indicator that we use for the evaluation of the net social benefit of a policy, program, or project is the benefit-cost ratio (BCR). The purpose of the benefit-cost ratio is to show the ratio of the present value of the benefits to the present value of the costs instead of showing the net present value in absolute terms. Consequently, the higher the ratio the more attractive the project is. Overall, the BCR attempts to summarise the overall value for money in a project. We calculate the BCR using the following formula:

$$(11) \quad BCR = \frac{PV(Benefits)}{PV(Costs)}$$

The BCR therefore expresses the proportion of benefits to costs.

## Benefit-Cost Ratio Decision Rule

The BCR is simply another way of expressing the NPV decision rule in a more intuitive method. If the present value of benefits are greater than the present value of costs, then we know that the NPV is positive.

This is equivalent to:

$$(12) \quad NPV = PV(Benefits) - PV(Costs) \geq 0$$

We know that:

$$(13) \quad PV(Benefits) \geq PV(Costs) \text{ then } NPV \geq 0$$

Hence, the decision rule for the BCR is to accept the project if the discounted benefits divided by the discounted costs (initial capital and ongoing costs) is greater or equal to 1. i.e.,

$$(14) \quad \frac{PV(Benefits)}{PV(Costs)} \geq 1$$

Following from this definition, we can highlight these results:

- 1) If the  $BCR < 1$  we should reject the project as the NPV would be negative. This also implies that the IRR of the project in question is less than the discount rate.
- 2) If the  $BCR = 1$  we are indifferent between accepting or rejecting the project as the NPV would be equal to zero and the IRR is equal to the discount rate.
- 3) If the  $BCR > 1$  we should accept the project as the NPV would be positive. This also implies that the IRR of the project is greater than the discount rate.

Overall this implies that when considering a project relative to the status quo, we accept the project if the  $BCR \geq 1$ . We reject a project if the  $BCR < 1$ . When comparing projects that are not mutually exclusive, we should accept all projects if the  $BCR \geq 1$ , assuming there are no budgetary constraints. *However, we should abstain from using the BCR when considering mutually exclusive projects or where there are budgetary constraints.*



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## Advantages of the Benefit-Cost Ratio

The advantage of the benefit-cost ratio is it indicates the value the policy, program, or project generates per dollar in costs. The BCR also accounts for the time value of money as it uses the discounted benefits and costs in the calculation.

## Limitations of the Benefit-Cost Ratio

The BCR method provides no additional information that was not already provided by the NPV method. However, when using the BCR we lose information relating to the magnitude of the project. For example, if we are considering two projects as follows:

- Project A:  $PV(\text{Benefits}) = \$10,000$  and  $PV(\text{Costs}) = \$2,000$ . Therefore, the  $BCR = \$10,000 / \$2,000 = 5$
- Project B:  $PV(\text{Benefits}) = \$500$  and  $PV(\text{Costs}) = \$100$ . Therefore, the  $BCR = \$500 / \$100 = 5$

Secondly, the benefit-cost ratio can result in the incorrect ranking of mutually exclusive projects. Therefore, we can use the BCR to evaluate the efficacy of a single project, but it should not be used to rank projects as it may result in the acceptance of projects that are not as allocative efficient as the best choice from the NPV method.

### Example 2.12

Suppose we are considering the following mutually exclusive projects which are within our budget. Assume that Project A and Project B follow a conventional net benefit stream where there is an initial cost in year 0 and benefits accrued across years 1-5.

**Table 2.13: Benefit-Cost Ratio and NPV Comparison**

Year	0	1	2	3	4	5
<b>Project A</b>	-1000	300	300	300	300	300
<b>Project B</b>	-2000	550	550	550	550	550

If the appropriate discount rate is 5%. We can calculate the NPV of both Project A and Project B

Calculating the NPV of Project A:

$$\begin{aligned}
 NPV_A &= -1,000 + \frac{300}{(1 + 0.05)} + \frac{300}{(1 + 0.05)^2} + \frac{300}{(1 + 0.05)^3} \\
 &\quad + \frac{300}{(1 + 0.05)^4} + \frac{300}{(1 + 0.05)^5} \\
 &= 298.84
 \end{aligned}$$

Calculating the NPV of Project B:

$$\begin{aligned}
 NPV_B &= -2,000 + \frac{550}{(1 + 0.05)} + \frac{550}{(1 + 0.05)^2} + \frac{550}{(1 + 0.05)^3} \\
 &\quad + \frac{550}{(1 + 0.05)^4} + \frac{550}{(1 + 0.05)^5} \\
 &= \$381.21
 \end{aligned}$$

Based on the NPV decision rule  $NPV_B > NPV_A$ , therefore we would accept project B.

However, if we look at the BCR we see a different story:

$$\begin{aligned}
 BCR_A &= \frac{\frac{300}{(1+0.05)} + \frac{300}{(1+0.05)^2} + \frac{300}{(1+0.05)^3} + \frac{300}{(1+0.05)^4} + \frac{300}{(1+0.05)^5}}{1000} \\
 &= \mathbf{1.30}
 \end{aligned}$$

and

$$\begin{aligned}
 BCR_B &= \frac{\frac{550}{(1+0.05)} + \frac{550}{(1+0.05)^2} + \frac{550}{(1+0.05)^3} + \frac{550}{(1+0.05)^4} + \frac{550}{(1+0.05)^5}}{2000} \\
 &= \mathbf{1.19}
 \end{aligned}$$

Example 2.12 shows that in the instance where the BCR was the only information we have for our decision-making, we would be making the wrong project choice which would lead to an inefficient allocation of our

available resources. This BCR result is therefore misleading. Consequently we should always use the NPV for ranking decisions.

## NPV vs BCR Decision Rule

As a consequence of the limitations of the BCR, it is clear that we should preference the NPV decision rule when comparing multiple projects in the case where the projects are mutually exclusive. Again, this is because the NPV decision will lead to the maximisation of the net benefit which is therefore more allocatively efficient.

## EXCEL Skills

If you have never used excel before, please refer to this [Youtube video by GCFLearn.org](https://www.youtube.com/watch?v=GCFLearn.org) that explains how to open Excel and get started with the available ribbon tabs.

### Revision



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## Summary of Learning Objectives

1. Projects, programs, or policies can have short-term impacts or long-term impacts. Discounting allows an analyst to account for the period of time for which the benefits and costs accrue.
2. The present value of a project can be discounted over a single period or multiple periods. Future values can be compounded over a single period or multiple periods where appropriate.
3. There are three key methods for evaluating the net social benefit: (1) the Net Present Value, (2) the Internal Rate of Return and the (3) Benefit-Cost Ratio.
4. The NPV decision rule is preferred in cost-benefit analysis.

### References

- Stokey, E., & Zeckhauser, R. (1978). *A primer for policy analysis*. W. W. Norton.
- Bierman, J. R., & Smidt, S. (2012). *The capital budgeting decision: economic analysis of investment projects*. Routledge.

# CHAPTER 3: CHALLENGES FOR COMPARING NET BENEFITS

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## Learning Objectives

After completing this chapter, students should be able to:

1. Calculate the NPV using mid-year and beginning of year discounting.
2. Apply the rollover and equivalent annual net benefit methods to address projects with unequal time frames.
3. Modify a basic CBA to account for salvage/scrap value.
4. Apply perpetuity formulae.

## Timing of Discounting and NPV calculations

In [Chapter 2](#), it was assumed that the benefits and costs are realised at the end of each year when compounding or discounting with the exception of the initial investment cost that may be incurred. This assumption is reasonable for many projects. However, it is important for a holistic view of social cost-benefit analysis to consider what happens when the timing of impacts changes. More specifically, we should consider what will happen to the NPV when we use alternative timing of benefits and costs.

## Timelines and NPV calculations

If we assume there is a project with an initial investment cost of \$10,000 in year 0 and a net benefit for each

year of \$5,000 over a three-year period, the timeline for the project using end of year discounting will follow the following format described in Figure 3.1.



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*Figure 3.1: Timeline of an Example Project with Investment Cost of \$10,000 and a \$5,000 Benefit per Year for 3 Years.*

Subsequently, the net benefit that occurs at Year 1 refers to the net benefit that occurs at the end of the first period we are accounting for in the project. Similarly, Year 2 represents the end of the second year and Year 3 represents the end of the third year the project runs. Remembering that the NPV formula is:

$$(1) \quad NPV_{end} = \sum_{t=0}^t \frac{NB_t}{(1 + dr)^t}$$

Assuming a 5% discount rate, we can calculate the NPV for this project:

$$\begin{aligned} NPV_{end} &= -\$10,000 + \frac{\$5000}{(1 + 0.05)^1} + \frac{\$5000}{(1 + 0.05)^2} + \frac{\$5000}{(1 + 0.05)^3} \\ &= \$3,616.24 \end{aligned}$$



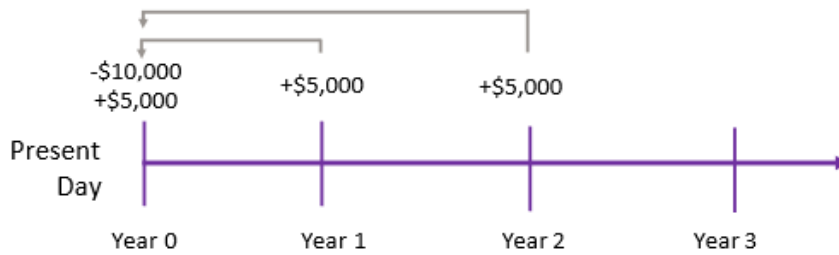
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## Beginning of Year Discounting

By convention, year 0 refers to the net benefit occurring right now. Therefore, if the benefits and costs are incurred at the beginning of the year the net benefit streams move forward in the timeline. If we consider the same \$10,000 initial investment with the \$5,000 of benefits occurring at the beginning of each year the timeline will look like:

Figure 3.2: Beginning of Year Discounting.



Note that the net benefit stream received at the end of year 1 is the same as receiving a benefit at the beginning of year 2. Hence the formula from equation (1) can be adjusted to reflect this:

$$(2) \quad NPV_{beginning} = NB_0 + \sum_{t=1}^t \frac{NB_t}{(1 + dr)^{t-1}}$$

Therefore, the NPV using beginning of year net benefit streams using a 5% discount rate can be found as follows:

$$\begin{aligned} NPV_{beginning} &= -\$10,000 + \$5,000 + \frac{\$5000}{(1 + 0.05)^1} + \frac{\$5000}{(1 + 0.05)^2} \\ &= \$4,297.05 \end{aligned}$$

From the formula, we can already observe that the NPV using beginning of year discounting is expected to be higher than using end of year discounting as we are using smaller discount factors. More specifically, we apply a discount factor of 1 to the initial investment cost and the first net benefit stream which is received at the beginning of year 1 (equivalent to year 0). The discount factor for year 2 would be  $1/(1 + 0.05)^{2-1} = 1/(1 + 0.05) = 0.9524$  and the discount factor for year 3 would be  $1/(1 + 0.05)^{3-1} = 1/(1 + 0.05)^2 = 0.9070$ . As the discount factors are higher for beginning of year discounting compared to end of year discounting, the NPV using beginning of year discounting will consequently be higher.



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## Mid-Year Discounting

Mid-year discounting is more common than beginning of year discounting as investment bankers often use this method to get a midpoint estimate for an investment choice. In CBA, this method is used when the benefit or costs are expected to occur over the course of the year.

$$(3) \quad NPV_{mid} = NB_0 + \sum_{t=1}^t \frac{NB_t}{(1 + dr)^{t-0.5}}$$

As suggested by equation 3, we are subtracting half a year from each time period discount using the midpoint of each year. If we consider the same \$10,000 initial investment with the \$5,000 of benefits occurring at the mid-point of year the timeline will look like:

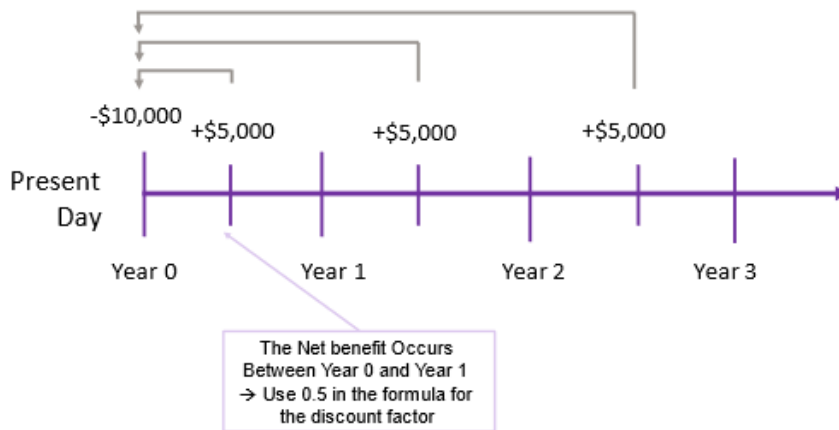


Figure 3.3:  
Mid-Year  
Discounting.

and the NPV using the midpoint formula can be calculated as follows:

$$\begin{aligned} NPV_{mid} &= -\$10,000 + \frac{\$5000}{(1 + 0.05)^{0.5}} + \frac{\$5000}{(1 + 0.05)^{1.5}} + \frac{\$5000}{(1 + 0.05)^{2.5}} \\ &= \$3,952.49 \end{aligned}$$



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## Why Assume End of Year Discounting?

Discounting using the assumption of end of year impacts for both costs and benefits in the policy, project, or program being evaluated always provides a more conservative NPV. The idea is to “err on the side of caution” by using the end of year discounting method. Consequently, if the  $NPV > 0$  for the end of year discounting method, it is implied that the NPVs would be larger for the mid-year and beginning of year discounting methods. This is illustrated in Example [3.1](#).

### Example 3.1

#### Comparison of Results Using Excel

Table 3.1: A Comparison of Beginning, Mid and End of Year Discounting

(1)	(2)	(3)	(4)	(5)	(6)	(7)	
Time Period	Benefits	Costs	Net Benefit (1) - (2)	End of Year Discount Factor $(1/(1 + dr)^t)$	Beginning of Year Discount Factor $(1/(1 + dr)^{t-1})$	Mid-Year Discount Factor $(1/(1 + dr)^{t-0.5})$	PV Mid Year Discounting $(FV/(1 + dr)^{t-0.5})$
0		1000	-1000	1.0000	1.0000	1.0000	-1000
1	550	200	350	0.9524	1.0000	0.9759	341.57
2	600	200	400	0.9070	0.9524	0.9294	371.77
3	650	200	450	0.8638	0.9070	0.8852	398.33
4	700	200	500	0.8227	0.8638	0.8430	421.51
5	750	200	550	0.7835	0.8227	0.8029	441.58



To calculate the NPV of each project in Excel you can use the “=NPV()” function for both End of Year and Beginning of year discounting. Remember that when using the “=NPV()” function for beginning of year discounting the values should start at year 2 for the appropriate discount factor to be applied. This will result in Excel treating the value from year 2 as a year 1 benefit stream to be discounted. Alternatively, you can calculate columns (4) and (5) to find the appropriate discount factor and multiply the net benefit in column (3) with the discount factor and sum the result.

Calculating mid-year discounting is more complicated as Excel is not set up for mid-year discounting calculations. Therefore, to calculate the result of mid-year discounting you can do it one of two ways:

(1) Calculate the appropriate discount factor for each of the time periods i.e., use  $1/(1 + dr)^{t-0.5}$  as shown in column (6). Then use the discount factor to calculate the present value of each net benefit, then sum these net benefits to get the correct result. i.e.

$$\begin{aligned}
 NPV_{mid} &= -1,000 \times df_0 + 350 \times df_1 + 400 \times df_2 + 450 \times df_3 + 500 \times df_4 + 550 \times df_5 \\
 &= -1,000 + 350 \times 0.9759 + 400 \times 0.9294 + 450 \times 0.8852 + 500 \times 0.8430 + 550 \times 0.8029 \\
 &= \$974.75
 \end{aligned}$$

(2) Apply the formula in 3 directly to each net benefit stream as shown in column (6) and illustrated in Figure 3.4 to find the present value of each net benefit stream. After this, you only need to use the “=sum()” function to sum the column to calculate the NPV as shown in Figure 3.5.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	
Time Period	Benefits	Costs	Net Benefit (1) - (2)	End of Year Discount Factor $1/(1+dr)^t$	Beginning of Year Discount Factor $1/(1+dr)^{t-1}$	Mid-Year Discount Factor $1/(1+dr)^{t-0.5}$	PV Mid Year Discounting $FV/(1+dr)^{t-0.5}$
0		1000	-1000	1.0000	1.0000	1.0000	-1000
1	550	200	350	0.9524	1.0000	0.9759	=E5/(1+\$I\$4)^(B5-0.5)
2	600	200	400	0.9070	0.9524	0.9294	371.77
3	650	200	450	0.8638	0.9070	0.8852	398.33
4	700	200	500	0.8227	0.8638	0.8430	421.51
5	750	200	550	0.7835	0.8227	0.8029	441.58
							974.75 <-NPV Mid-Year Disc.
End of Year NPV	\$927.16						
Mid-Year NPV	\$974.75						
Beginning of Year	\$1,023.52						

Figure 3.4:  
Calculating NPV  
using the Mid Year  
Discounting  
Formula

(1)	(2)	(3)	(4)	(5)	(6)	(7)	
Time Period	Benefits	Costs	Net Benefit (1) - (2)	End of Year Discount Factor $1/(1+dr)^t$	Beginning of Year Discount Factor $1/(1+dr)^{t-1}$	Mid-Year Discount Factor $1/(1+dr)^{t-0.5}$	PV Mid Year Discounting $FV/(1+dr)^{t-0.5}$
0		1000	-1000	1.0000	1.0000	1.0000	-1000
1	550	200	350	0.9524	1.0000	0.9759	341.57
2	600	200	400	0.9070	0.9524	0.9294	371.77
3	650	200	450	0.8638	0.9070	0.8852	398.33
4	700	200	500	0.8227	0.8638	0.8430	421.51
5	750	200	550	0.7835	0.8227	0.8029	441.58
						<b>=sum(14:19)</b>	<b>&lt;-- NPV Mid-Year Disc.</b>
End of Year NPV	\$927.16						
Mid-Year NPV	\$974.75						
Beginning of Year	\$1,023.52						

Figure 3.5: Using the =sum() function in Excel

(1)	(2)	(3)	(4)	(5)	(6)	(7)	
Time Period	Benefits	Costs	Net Benefit (1) - (2)	End of Year Discount Factor $1/(1+dr)^t$	Beginning of Year Discount Factor $1/(1+dr)^{t-1}$	Mid-Year Discount Factor $1/(1+dr)^{t-0.5}$	PV Mid Year Discounting $FV/(1+dr)^{t-0.5}$
0		1000	-1000	1.0000	1.0000	1.0000	-1000
1	550	200	350	0.9524	1.0000	0.9759	341.57
2	600	200	400	0.9070	0.9524	0.9294	371.77
3	650	200	450	0.8638	0.9070	0.8852	398.33
4	700	200	500	0.8227	0.8638	0.8430	421.51
5	750	200	550	0.7835	0.8227	0.8029	441.58
							<b>974.75</b> <-- NPV Mid-Year Disc.
End of Year NPV	\$927.16						
Mid-Year NPV	\$974.75						
Beginning of Year	\$1,023.52						

Figure 3.6: Final Result using the Mid Year Discounting Method

Click here to download the spreadsheet: [Example\\_3\\_1.xls](#)

## Approximating Mid-Year Discounting

An alternative method that is sometimes adopted is to calculate the NPV under the beginning of year and end of year discounting methods and take the average of the two results. This gives a close approximation of mid-year discounting.

### Example 3.2

Approximate the mid-year discounted NPV using the average of the end and beginning of year results using the information in Table 3.2.

**Table 3.2: Net Benefits of a Project**

Year	Net Benefit
0	-800
1	300
2	300
3	300

Assuming a 6% discount rate we can calculate the NPV using the beginning of year method as illustrated in Figure 3.7 below:

	A	B	C	D	E	F	G
1							
2		Year	Net Benefit				
3		0	-800		Discount Rate	6%	
4		1	300				
5		2	300		NPV	=NPV(F3,C5:C6)+C3+C4	
6		3	300			=NPV(rate, values) - initial cost in year 0	
7						+ year 1 benefit	

Figure 3.7:  
Beginning of Year  
Discounting in  
Excel using the  
=NPV() function

The end of year NPV can also be calculated as illustrated in Figure 3.8 below::

	A	B	C	D	E	F	G
1							
2		Year	Net Benefit				
3		0	-800		Discount Rate	6%	
4		1	300				
5		2	300		NPV	=NPV(F3,C4:C6)+C3	
6		3	300			=NPV(rate, values) - initial cost in year 0	

Figure 3.8:  
Reminder of End  
of Year  
Discounting from  
Example 2.4

Taking the average of these results (\$1.90 and \$50.02 respectively) will give a value of \$25.96 which is a close approximation of the mid-year discounted NPV.

To replicate this result and to practice beginning and end of year discounting you can download the spreadsheet here: [Example3\\_2](#)

See if you can replicate the result by calculating this by hand as well.



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## Comparing Projects with Different Time Frames

When comparing projects, it has been assumed that the period for the life of the project was equal. However, we know that this is not necessarily the case for real world decision-making as the NPVs of projects with different time frames are not directly comparable. For example, as CBA analysts we may be asked to compare the life of a road infrastructure project against a new solar farm. To make valid comparisons we look at two methods: (1) the equivalent annual net benefit (EANB); and (2) project roll-over. The choice of which method is most appropriate for comparison depends on whether it is possible to repeat a project investment.

### Equivalent Annual Net Benefit (EANB)

The **equivalent annual net benefit** identifies a yearly annuity received for the life of a project. An **annuity** is a fixed sum of money paid or received per year. Common annuities include mortgage repayments or salary payments. Identifying the equivalent annual net benefit involves taking the NPV of the project and dividing it by the annuity factor to find a per year net benefit stream.

$$(4) \quad EANB = \frac{NPV}{AnnuityFactor(AF)}$$

Therefore, when you sum the total present value of the annuity series across the life of the project it must be equal to the total NPV of the project. Specifically,

$$NPV = \sum_{t=0}^t PV(EANB \text{ Annuity})$$

where  $t$  is the number of years or life of the project.

By calculating the EANB, we determine the amount of net benefit received per year for the life of a project i.e., the yearly annuity benefit. Therefore, the sum of these annuity benefits will be equal to the NPV of the project under consideration.

$$(5) \quad NPV = Annuity \times Annuity \text{ Factor } (AF)$$

When comparing projects with unequal lives using EANB, we should select the project with the highest EANB – assuming we are not attempting to minimise net costs but seeking to maximise total net benefits.<sup>1</sup>

## Annuity Factor

To effectively calculate the EANB in equation (4), we need to first calculate the annuity factor. The annuity factor is the sum of the discount factors over the life of the project where the stream of net benefits follows a fixed annuity format. As outlined in [Chapter 2](#), the discount factor is:

$$(6) \quad \text{Discount Factor} = \frac{1}{(1 + dr)^t}$$

To demonstrate this relationship between the discount factor and the annuity factor, consider the following example in [Table 3.3](#), with end of year discounting and a social discount rate of 6%:

**Table 3.3: The Relationship Between the Discount Factor and Annuity Factor**

Year	Net Benefit	Discount Factor
0	-800	
1	400	0.9434
2	400	0.8900
3	400	0.8396
		<b>AF = 2.6730</b>

The discount factors across years 1 – 3 are:

$$DF_1 = \frac{1}{(1 + 0.06)^1} = 0.9434$$

$$DF_2 = \frac{1}{(1 + 0.06)^2} = 0.8900$$

$$DF_3 = \frac{1}{(1 + 0.06)^3} = 0.8396$$

Therefore, the annuity factor would be 2.6730. As can be seen from the example above, there is a geometric sequence with the common ratio of  $1/(1 + dr)$ . Therefore, we can summarise the annuity factor in the following equation:

$$(7) \quad AF = \frac{1 - (1 + dr)^{-t}}{dr}$$

1. Alternatively if the project only runs at a cost, we can calculate the equivalent annual net cost and select the project which minimises the cost.

where  $dr$  is the discount rate and  $t$  is the number of years/life of the project.

Hence, the annuity factor represents the present value of an annuity of \$1 per year for  $t$  years when the discount rate is  $dr$ .

### Key concept – Annuity Factor

The annuity factor represents the present value of an annuity of \$1 per year for  $t$  years when the discount rate is  $dr$ .

Substituting in the same values as before we can confirm the result for the annuity as follows:

$$AF = \frac{1 - (1 + 0.06)^{-3}}{0.06} = 2.6730$$

This is reflected in the sum of the discount factors in Table 3.3.

Calculating the NPV of this project gives a value of \$269.21. Therefore, applying equation (4), we calculate the EANB as \$100.71. This EANB implies that the project has an equivalent annual benefit annuity of \$100.71 per year across the three-year life of the project. Note that if we receive \$100.71 per year across three years and then discount this benefit back at the same discount rate we will receive a total approximately \$269.21 as highlighted in Table 3.4 below:

**Table 3.4: Equivalent Annual Net Benefit and the NPV**

Year	0	1	2	3
<b>EANB Per Year (annuity stream)</b>		100.71	100.71	100.71
<b>Discounted EANB</b>		95.01	89.63	84.56
<b>NPV (sum discounted EANB)</b>	269.20			

To replicate this example in Excel, you can download the spreadsheet here: [Table3\\_4](#)



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## Annuity Factor and EANB in Perpetuity

### Key Concept – Perpetuity

A perpetuity is an annuity that has no end, or a stream of cash payments that continues forever.

When comparing projects with different time frames, we may come across the situation where a project does not have an end for the net benefit stream. This is known as a **perpetuity**. One thing we note about the annuity factor in equation (7), as the number of years increases (i.e.  $t \rightarrow \infty$ ), the annuity factor in perpetuity becomes  $AF = 1/dr$ . Consequently, if we have two mutually exclusive projects A and B:

- Project A is a solar farm. It has NPV of \$20 and a life of 25 years
- Project B is a hydroelectric plant has a NPV \$30 million and continues in perpetuity.

We can calculate the EANB for both projects to compare which project should be selected. Assuming the appropriate discount rate is 4%, we calculate the annuity factor for Project A we apply equation (4) resulting in an  $AF_a = 15.62$  and a  $EANB_a = 20/15.62 = 1.28$  million per year across 25 years.

For project B we need to apply the annuity factor for a perpetuity  $AF = 1/dr$ . Therefore the  $AF_b = 1/0.04 = 25$ . Consequently, we then calculate the  $EANB_b$  as  $30/25 = 1.20$  million per year in perpetuity.

From these results we can see that  $EANB_a > EANB_b$  therefore Project A should be selected.

We will see the implications of perpetuities for [NPVs below](#).

## Advantages and Disadvantages of EANB

Calculating the EANB is a good option for comparing projects with unequal lives as it annualizes the NPV allowing for a per year net social benefit comparison between projects on a per year common metric. Therefore, EANB can be used to rank projects and will subsequently provide a consistent decision when comparing projects with unequal lives.

The biggest limitation of the EANB method for project comparison is the selection of the discount rate. As shown in equation (6), there is an inverse relationship between the discount rate and the discount factor.

## Example 3.3

### Equivalent Annual Net Benefit Example

If we are considering two possible projects that are mutually exclusive:

- Project A: Benefit = \$40,000 per year, Initial Cost = \$ 15,000 in year 0, life = 3 years
- Project B: Benefit = \$30,000 per year, Initial Cost = \$ 10,000 in year 0, life = 4 years

If the appropriate discount rate is 5%. We can calculate the EANB for each project in three steps.

#### Step 1: Calculate the NPV of each project

In this case the values are already expressed in present values therefore we can take the difference between the PV(B) and PV(C).

$$\begin{aligned} NPV_a &= -15,000 + \frac{40,000}{(1.05)} + \frac{40,000}{(1.05)^2} + \frac{40,000}{(1.05)^3} \\ &= \$93,929.92 \end{aligned}$$

$$\begin{aligned} NPV_b &= -\$10,000 + \frac{30,000}{(1.05)} + \frac{30,000}{(1.05)^2} + \frac{30,000}{(1.05)^3} + \frac{30,000}{(1.05)^4} \\ &= \$96,378.52 \end{aligned}$$

#### Step 2: Find the annuity factor

$$AF_a = \frac{1 - (1 + 0.05)^{-3}}{0.05} = 2.7232$$

And

$$AF_b = \frac{1 - (1 + 0.05)^{-4}}{0.05} = 3.5460$$

#### Step 3: Calculate the EANB



$$EANB_a = \frac{NPV_a}{AF_a} = \frac{\$93,929.92}{2.7232} = \$34,491.87$$

$$EANB_b = \frac{NPV_b}{AF_b} = \frac{\$96,378.52}{3.5450} = \$27,179.88$$

As we are measuring net social benefit when comparing these projects, we select the project with the highest EANB. Hence, project A should be accepted as  $EANB_a > EANB_b$

To complete this example in Excel, you can download the following spreadsheet: [Example3\\_3](#)

## Example 3.4

One of the challenges of using Equivalent Annual Net Cost (EANC) instead of EANB is to remember that you are evaluating the cost effectiveness of a project. Therefore the net benefit stream will be negative. Therefore, you should select the project that minimises cost annuity. In this instance the project will still have the highest value, as the annuity calculated will be closer to zero. To see this, consider the following information on three mutually exclusive projects below:

**Table 3.5: Calculating the Equivalent Annual Net Cost**

Project	NPV Cost	Life (years)
(1)	(2)	(3)
<b>X</b>	-3,500	2
<b>Y</b>	-4,500	3
<b>Z</b>	-6,000	4

Project X has a two-year life, Project Y has a three-year life and Project Z has a four-year life. The present value of each project across the life is already calculated for the first step in column (2).

The second step is to calculate the annuity factor for each project. Assuming the appropriate discount rate is 10% the annuity factor for a two-year project is 1.7355, 2.4869 for a three-year project and 3.1699 for a four-year project. Therefore, the EANC for each project can be calculated as below:

$$\begin{aligned} EANC_X &= \frac{-3,500}{1.7355} \\ &= -\$2,016.67 \end{aligned}$$

$$\begin{aligned} EANC_Y &= \frac{-4,500}{2.4869} \\ &= -\$1,809.52 \end{aligned}$$

$$\begin{aligned} EANC_Z &= \frac{-6,000}{3.1699} \\ &= -\$1,892.82 \end{aligned}$$

These results indicate that Project Y is the least costly option and therefore should be selected.

To replicate these results in excel you can download the spreadsheet here: [Example3\\_4](#)

## Project Roll-over

The project roll-over method involves making the length of both projects the same by assuming the ability to “roll-over” or reinvest in the same projects repeatedly until an equal project life is achieved. This is often called the “common life” approach in capital budgeting.

If we consider two projects:

- Project X – has a life of *six* years, an initial cost of \$60,000 and a yearly net benefit stream of \$15,000
- Project Y – has a life of *three* years, an initial cost of \$40,000 and a yearly net benefit stream of \$20,000

Assuming all benefits and costs accrue at the end of the year and the appropriate social discount rate is 6%, the project timelines and NPV for Project X can be illustrated as shown in [Figure 3.9](#):



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*Figure 3.9: Timeline of Net Benefits for Project X.*

Consequently, the NPV for Project X is found as follow:

$$\begin{aligned} NPV_X &= -\$60,000 + \frac{\$15,000}{(1 + 0.06)} + \frac{\$15,000}{(1 + 0.06)^2} + \dots + \frac{\$15,000}{(1 + 0.06)^6} \\ &= \$13,759.86 \end{aligned}$$

The timeline for Project Y is different as the project only spans 3 years as illustrated in Figure 3.10:



An interactive H5P element has been excluded from this version of the text. You can view it online here:

<https://uq.pressbooks.pub/socialcba/?p=291#h5p-30>

*Figure 3.10: Timeline of Net Benefits for Project Y.*

Therefore, the NPV of Project Y is:

$$\begin{aligned} NPV_Y &= -\$40,000 + \frac{\$20,000}{(1 + 0.06)} + \frac{\$20,000}{(1 + 0.06)^2} + \frac{\$20,000}{(1 + 0.06)^3} \\ &= \$13,460.24 \end{aligned}$$

When the projects are considered mutually exclusive, the NPV decision rule implies we should accept Project X over Project Y. However, this decision is not correct as we know the projects, we are comparing have unequal lives. Therefore, if we assume Project Y can be rolled over and reinvested we can equate the timeline of Project Y to an equivalent time frame as Project X shown in Figure 3.11:



An interactive H5P element has been excluded from this version of the text. You can view it online here:

<https://uq.pressbooks.pub/socialcba/?p=291#h5p-31>

*Figure 3.11: Timeline of Net Benefits for Project Y when the Project is Rolled Over.*

Therefore the NPV of Project Y should be calculated as:

$$\begin{aligned}
 NPV_Y &= -\$40,000 + \frac{\$20,000}{(1 + 0.06)} + \frac{\$20,000}{(1 + 0.06)^2} + \frac{\$20,000}{(1 + 0.06)^3} \\
 &\quad - \frac{\$40,000}{(1 + 0.06)^3} + \frac{\$20,000}{(1 + 0.06)^4} + \frac{\$20,000}{(1 + 0.06)^5} + \frac{\$20,000}{(1 + 0.06)^6} \\
 &= \$24,761.72
 \end{aligned}$$

Following this, we can compare the two Project NPV's with roll over in outlined in Figure 3.12. As can be seen from the project roll-over of Y the  $NPV_y$  is now higher than the  $NPV_x$  when Project Y is rolled across the same number of years.

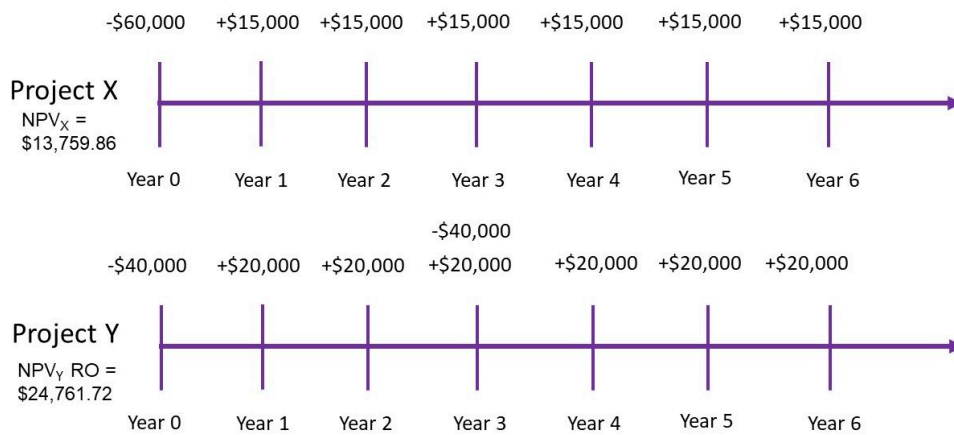


Figure 3.12: Comparing the Timelines for the NPV of Project X and Project Y

Alternatively, you can rewrite the formula for the NPV project roll-over as

$$(8) \quad NPV_{Roll-over} = NPV_0 + \sum \frac{NPV_0}{(1 + dr)^{(t-n)}}$$

Where:

- $NPV_0$  = the initial NPV of the project for the normal life span
- $dr$  = is the discount rate
- $t$  = is the total number of periods required for roll-over
- $n$  = is the initial project duration

Following the same example as above for Project Y:

$$NPV_Y = \$13,460.24 + \frac{13,460.24}{(1 + 0.06)^{6-3}}$$

$$NPV_Y = \$13,460.24 + \frac{13,460.24}{(1.06)^3}$$

$$NPV_Y = \$13,460.24 + \$11,301.48$$

$$= \$24,761.72$$

This is also illustrated in Figure 3.13 below:



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<https://uq.pressbooks.pub/socialcba/?p=291#h5p-32>

*Figure 3.13: Applying the Roll-Over Method*

Consequently, from the project roll-over approach – we should accept Project Y over Project X if the projects are mutually exclusive and reinvestment into Project Y is possible.

You can download the spreadsheet to complete this example [Chapter3 Roll Over Example](#)

In conclusion we can see from both the EANB method, and the Project Roll-over method illustrated in the sections above, we cannot just use the NPV decision rule when comparing projects with unequal lives. Instead, we should ensure we are comparing “apples with apples” by using either the EANB or roll-over comparisons depending on the assumptions around re-investment opportunities.

## Other Complications in CBA

### Real vs Nominal Values

One issue we often need to consider when conducting a cost-benefit analysis is whether to use real or nominal values to value the expected impacts. It is usually more convenient and less confusing to use real values (constant year 0 prices). Using nominal values requires the analysts to determine the prices of impacts in each year across the life of the project. In addition to this, when using nominal values, you should use a nominal social discount rate. This can add an additional layer of complexity to the analysis. When using real values, you can use the real social discount rate observed in year 0 for the life of the project. Following this approach, we adopt the use of “constant year 0 values” or “real values” as these are most appropriate for *ex-ante* CBA.

### Key Concept – Real Values

For the purpose of this course, we assume real values at constant year 0 prices and the social discount rate at year 0 across the life of a project.

## Dealing with Inflation and Growth

We know that benefits and costs of a policy, program, or project being evaluated often occur in the future. By using real terms for evaluation of the project under consideration, we neutralise the impact of inflation in the analysis as all impacts are measured in a constant year 0 price. For practical purposes, it is safe to assume that the prices will remain relatively constant to all other aspects of the economy, so unless we expect the sector under evaluation to experience rapid disproportionate changes relative to the rest of the economy, it is reasonable to use real terms to ignore inflation.

Financial appraisal usually deals with the issue of inflation. Usually, we are approaching the evaluation of public projects from a social perspective, which implies inflation can be ignored to an extent. However, it is important to ensure that we can account for inflation where necessary when a private firm is involved in the project. Consequently, it is important to note that from a financial appraisal perspective the discount rate is often substituted with the real interest rate for an investment and the analysis will capture the impacts of inflation on a project. Therefore, it is important to understand the relationship between nominal and real interest rates. In a project appraisal, a private firm may adjust the cashflows of a project using the following real interest rate formula:

$$(9) \quad r = \frac{i - m}{1 + m}$$

where

$r$  = the real interest rate

$i$  = the nominal interest rate

$m$  = inflation rate

In the context where evaluation of a project occurs over many periods with large values, it is not considered appropriate to use the approximation formula as it may impact the NPV calculations.

It is usual to undertake ex-ante CBAs in real terms and financial appraisals in nominal terms. Also note that when conducting an ex-post CBA we use the nominal prices that were observed in the past. This allows the analyst to determine the precision of the results and provides an opportunity to refine future CBAs.

### Key Concept – Discount Rate versus Interest Rate

The discount rate in social cost-benefit analysis is different to the interest rate used in financial appraisals and therefore we often ignore the implications of inflation on the project evaluation.

### Example 3.5

If the nominal interest rate is 5% and the inflation rate is 2%, we can calculate the real interest rate as:

$$\begin{aligned} r &= \frac{0.05 - 0.02}{1 + 0.02} \\ &= 2.94 \end{aligned}$$



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## Example 3.6

Suppose we have an investment that provides a real net benefit of \$230 per year over 5 years, at a cost of \$1,000 at the beginning of the project.

If the inflation rate is expected to be 5% each year over the life of the project, we can calculate the nominal net benefits in each year.

**Table 3.6: Real Versus Nominal Values for Net Benefits**

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5
<b>Net Benefit (Year 0)</b>	-1,000	230	230	230	230	230
<b>Net Benefit (Nominal – Current Year)</b>	-1,000	241.5	253.58	266.25	279.57	293.54

Calculating the internal rate of return, we get a nominal IRR of = 10.1% and NPV of \$118 when we assume a 6% discount rate. When using current year prices (i.e. year 0 prices), we get the real IRR of 4.6% and an NPV of -\$31.

In some cases, this would lead an investor to believe that the rate of return is better for the project under nominal terms. However, this is not true. It is the same project! The measurement is just different as we have expressed the net benefit in nominal terms compared to real terms. Consequently, we need to be cautious when using nominal values for our analysis.

If we were using an IRR rule, we need to ensure that we compare the cost of capital in real terms when using real values or nominal terms when using nominal values. Therefore, we would need to use the formula in (9) to adjust between real and nominal values.

To practice calculating the NPV and IRR you can download the spreadsheet for this example here: [Example3\\_6](#)

## Horizon/Terminal Values

We usually assume that the benefits and costs of a project are accrued over a set time frame. However, when it comes to capturing social costs and benefits, we are likely to experience impacts into the future, beyond the life of the project. When we consider policies where benefits and costs that may continue past the scope of evaluation, we need to ensure we capture these impacts in our social cost-benefit analysis.



For example, if the government implemented a program that involved early childhood reading activities in pre-school care programs, the benefits from the intervention would likely impact the children involved in the program across their whole life and even potentially produce intergenerational impacts. However, the scope of evaluation for a program such as this would not be conducted across the lifetime of the individuals involved. Instead, the program or intervention would be evaluated within the timeframe set by the relevant government department.

This idea of impacts observed beyond the time frame used for the evaluation of a project is important. When conducting a social cost-benefit analysis, there is an expectation that the analysis captures all social costs and social benefits to ensure the accuracy of the results. Therefore, we as analysts face a challenge in measuring these potential benefits and costs. The solution to this is to utilise **horizon values**. Depending on the approach to social cost-benefit analysis for the project under evaluation, there are different methods for capturing the horizon value.

From a social cost-benefit perspective, the best approach is to calculate the benefits and costs accruing for the project in the form of a final expected benefit which can be discounted to the present. We can therefore calculate the appropriate NPV the following two ways:

1. Calculate the horizon value for the relevant duration and discount the horizon value to the present using the appropriate duration. i.e.  $NPV = PV(NetBenefits) + PV(HorizonValue)$ . Such that  $PV(HorizonValue) = HorizonValue / (1 + dr)^t$  where  $t$  is the appropriate duration for which the benefits and costs will accrue into the future.
2. Calculate the horizon value and treat it as a perpetuity i.e.,  $HorizonValue = FutureValue / DiscountRate$ . This method is useful when a duration cannot be effectively determined.

From a financial appraisal perspective, the salvage value (sometimes referred to as residual value or scrap value) can be used as a proxy for the horizon value. This salvage value usually occurs in the last year of a project and requires discounting. Consequently the NPV of a project is therefore calculated as the  $NPV = PV(NetBenefits) + PV(SalvageValue)$ . This is a common approach in transportation and infrastructure evaluations. However, this approach assumes that market prices reflect the true social value of the underlying project being evaluated. In real world applications, salvage values can be positive or negative depending on whether the project investor would receive a positive cash flow from on-selling the remnants of the project or whether there is a cost associated with disposing the remnants of the project. For example, a factory may sell their machinery at the conclusion of the project for a positive salvage value whereas mining projects often have a salvage cost for land rehabilitation.

### Key Concept – Salvage Value

Salvage Value is usually treated as a “negative cost” and not necessarily a positive benefit – implying a positive inflow for salvage that is accounted for in the cost section of an evaluation. Consequently, it will impact the BCR of a project if the salvage value is sufficiently large.

In some instances, the horizon value is set to zero. This approach assumes that there are no benefits and costs accruing to a project after the time frame used in the evaluation. This is the easiest method for dealing with the horizon value issue, however important benefits and costs may not be included in the social cost-benefit analysis. Consequently, the NPV may be underestimated or overestimated. For example, if we were considering the same government implemented for early childhood reading activities the NPV would likely be underestimated as the lifetime increases in earnings of participants would not be captured outside of the stated time frame. Therefore, although this is the easy method it can result in an inefficient allocation of the scarce resources.

Consequently, the decisions relating to how we approach horizon values need to be carefully considered when conducting a social cost-benefit analysis.



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### Example 3.7

Consider the following project

The initial cost is \$10,000

Annual Benefit of \$6,000

Immediate life of the project for evaluation is 3 years. Smaller spill over benefits are expected to accrue into the future over a 20-year period to the value of \$1,500 at the end of year 20. If the discount rate is 5%,

$$\begin{aligned}
 NPV &= PV(NetBenefits) + PV(HorizonValue) \\
 &= -10,000 + \frac{6,000}{(1 + 0.05)} + \frac{6,000}{(1 + 0.05)^2} + \frac{6,000}{(1 + 0.05)^3} + \frac{1,500}{(1 + 0.05)^{20}} \\
 &= \$6,339.49 + \$565.33 \\
 &= \$6,904.82
 \end{aligned}$$

## Example 3.8

Consider the same information as Example 3.7 above replicated in Table 3.6 below. Suppose instead of using a horizon value, we calculate a salvage value equal to 10% of the initial cost of investment. The immediate life of the project for evaluation is 3 years. Salvage occurs at the end of the project. If the discount rate is 5% we can determine the following:

**Table 3.6: Salvage Value Example**

Year	0	1	2	3
Initial Cost	-10,000			
Benefit Stream		6,000	6,000	6,000
Salvage Value				1,000

$$\text{Salvage Value} = 10\% \times \$10,000$$

$$\begin{aligned}
 NPV &= PV(NetBenefits) + PV(SalvageValue) \\
 &= -10,000 + \frac{6,000}{(1 + 0.05)} + \frac{6,000}{(1 + 0.05)^2} + \frac{6,000}{(1 + 0.05)^3} + \frac{1,000}{(1 + 0.05)^3} \\
 &= \$7,203.33
 \end{aligned}$$

To calculate this in Excel you can use the “=sum()” function to calculate the net benefit stream (shown in Figure 3.14). After pressing enter, you will have the sum of column C.

	A	B	C	D	E	F	G	H	I	J	K
1											
2		Year	0	1	2	3			Discount Rate	5%	
3		Initial Cost	-10,000								
4		Benefit Stream		6,000	6,000	6,000					
5		Salvage Value				1,000					
6		Net Benefit	=sum(C3:C5)				=SUM(values)				
7		Net Present Value									
8											
9											
10											
11											

Figure 3.14: Using the =sum() Function to Calculate the Net Benefit Stream

You can copy the formula across using the black plus symbol that appears when you hover at the bottom right corner of the cell “+” and Excel will calculate the same formula for each column as shown in Figure 3.15.

	A	B	C	D	E	F	G	H	I	J	K
1											
2		Year	0	1	2	3			Discount Rate	5%	
3		Initial Cost	-10,000								
4		Benefit Stream		6,000	6,000	6,000					
5		Salvage Value				1,000					
6		Net Benefit	-10,000	6,000	6,000	7,000	=SUM(values)				
7		Net Present Value									
8											
9											
10											
11											

Figure 3.15: The Result of Calculating the Net Benefit Stream in Row 6

Once this is complete, you can apply the “=NPV()” function as illustrated in Figure 3.16:

	A	B	C	D	E	F	G	H	I	J	K
1											
2		Year	0	1	2	3			Discount Rate	5%	
3		Initial Cost	-10,000								
4		Benefit Stream		6,000	6,000	6,000					
5		Salvage Value				1,000					
6		Net Benefit	-10,000	6,000	6,000	7,000					
7		Net Present Value	=NPV(I2,D6:F6)+C6								
8			=NPV(rate, values) - year 0 cost								
9											
10											
11											

Figure 3.16: Calculating the NPV of the Net Benefit Stream Using the =NPV() function

To replicate this result, you can download the spreadsheet here: [Example3\\_8](#)

As we can see from Example 3.7 and Example 3.8, the choice of how we approach the horizon value will impact the NPV. If we assumed that the horizon value was equal to zero, the NPV of

the project would be \$6,339.49, which is smaller than the NPVs where a horizon value was included.

## Present Values in Perpetuity

The final aspect we need to consider was briefly mentioned when discussing [horizon values as above](#). Some horizon values can be considered in perpetuity. If a benefit or cost is expected to accrue in perpetuity, we need to be able to calculate the present value of the perpetuity. To do so we apply the following formula:

$$(10) \quad PV = \frac{FV}{dr}$$

### Key Concept – Perpetuity

A perpetuity is a constant flow that occurs forever.

It is important to note that the present value of a perpetuity is not significantly different from the present value of an annuity over a long period, however it applying a perpetuity formula allows for a more conservative NPV estimation when applied to horizon values or similar issues that need to be accounted for in CBA.

### Example 3.9

Suppose there is a perpetuity benefit of \$250 per year. Assuming the appropriate discount rate is 10%, the present value of the benefit would be

$$PV(benefit) = \frac{250}{0.10} = 2,500$$

Suppose instead of assuming the benefit is in perpetuity and instead we apply a 35- year duration we calculate the PV of the benefit as

$$PV(benefit) = \frac{250}{(1+0.10)^1} + \frac{250}{(1+0.10)^2} + \dots + \frac{250}{(1+0.10)^{35}} = 2,411.04$$

## NPV in Perpetuity with Growth

If we also require the growth rate to be accounted for in our perpetuity calculation, we adjust the formula as follows:

$$(11) \quad PV = \frac{FV}{dr - \text{growth rate}}$$

However, CBA analysts often do not capture growth or inflation in the analysis as the preference is to use, constant real year 0 values to reduce complexity.

## Revision



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## Summary of Learning Objectives

1. The assumption that all costs and benefits are realised may not be appropriate for all projects. Therefore, it is important to be able to apply beginning and mid-year discounting.
2. When comparing projects with unequal timeframes, we can apply either the rollover method or the equivalent annual net benefit method. The assumptions of these methods are different.
3. We need to include scrap/ salvage values or horizon values to capture benefits or costs that persist after the evaluation period of the project. This is especially important if the horizon value or scrap value will significantly impact the net present value.
4. Some projects run in perpetuity and therefore it is appropriate to evaluate those projects using the perpetuity formula.



# CHAPTER 4: STANDING AND PERSPECTIVE IN CBA

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## Learning Objectives

After completing this chapter, students should be able to:

1. Identify and apply standing in cost-benefit analysis.
2. Evaluate the role of preferences in determining standing.
3. Describe the four perspectives (1) market, (2) investor, (3) social, and (4) distributional.

## Whose Benefits and Costs Matter?

When evaluating a policy, program, or project, an analyst will often face the question of whose benefits and costs matter. This issue is crucial for developing the concept of “standing” as part of the evaluation of a program’s impacts. All stakeholders who are affected by a policy, program, or project should be accounted for in the CBA.

A secondary issue faced by CBA analysts is which perspective should be used in the evaluation framework. The perspective component is related to the “players” involved in the CBA. Specifically, we have assumed that in the context of economic applications, a *social perspective* is appropriate to ensure we are effectively calculating the net social benefit from the perspective of a government. Social CBA is focused on evaluating projects based on impacts affecting society as a whole. So far, we have assumed that an analyst can effectively capture all positive and negative impacts, and then predict and monetise these

impacts from observed information. Nevertheless, this is not as easy as it seems because non-market impacts can be difficult to measure (which will be covered extensively in [Chapter 12](#)).

However, there are other perspectives that may be needed to evaluate a project. This chapter starts with the simplest approaches to CBA perspectives, including the market perspective and a firm's private perspective. These are often referred to as financial appraisals, financial analysis, or financial CBA. Once we understand these approaches to CBA, it becomes clearer how we can implement the relevant applications or economic theory to produce a social CBA perspective and the disaggregated social CBA.

## The Issue of Standing

The concept of standing was coined by [Whittington and MacRae \(1986\)](#). Standing involves the identification of whose benefit and whose costs should be accounted for in the analysis. Identification of those parties with standing allows for effective recognition of the benefits and costs that will be *explicitly* accounted for in the cost-benefit analysis. In general, a social CBA approach accounts for all impacts, and pinpoints who the benefits or costs accrue to. By identifying the “winners” and “losers” of a project, we consider which impacts need to be explicitly accounted for. Consequently, the problem of identifying those with standing, defines the scope of our analysis. This leads to a few questions:

- Whose preference matter?
- Which preferences should count?
- What are the challenges relating to identification of preferences and standing?

## Whose preferences matter?

Without defined standing, a cost-benefit analysis cannot be conducted. Standing determines the costs and benefits that are included in the calculation of the net present value (NPV). Therefore, it is a key component in the preliminary stages of the development of a CBA.

However, there is no “hard and fast” rule on how to identify the relevant parties with standing. The goal of defining standing is to evaluate the project for those who are most likely to be impacted either positively or negatively. If standing is not correctly identified, there can be bias introduced into the calculation of the NPV.

It is important to also note that often there are relevant protocols that outline the standing that should be used (see for example the comparison in [this paper by Abelson, 2020](#)). This is especially for the instances where CBA is used frequently by the public sector. Variations of standing exist between authorities, however the concept itself is the same – standing accounts for who the benefits and costs accrue.

Conceptually, the identification of standing is easiest when the analyst considers and assesses those groups who have experienced changes in income, capital, investments, time, etc. It is important to note that when determining standing, political and moral debates should not be considered. Best practice is to decide at the beginning of the CBA evaluation process – whose benefits and costs matter.

## Which preferences should count?

In application, all preferences of all individuals impacted by a policy, project, or program must be accounted for in the CBA. The purpose of understanding which preferences count is to ensure that groups or individuals who may be impacted have their welfare counted if they cannot express their own preferences regarding the project or intervention. For example, with the response to COVID-19 impacts associated with mental health, stress, fear, and anxiety should be accounted for when considering restrictions and lockdowns. Additionally impacts on child development would also need to be accounted for as primary and secondary students shift between online and face-to-face learning.

Overall, when considering which preferences matter, it is critical to be mindful of ethical and social impacts in the identification of standing issues.

## What are the challenges relating to identification of preferences and standing?

There are a few issues when considering which preferences to include or exclude when evaluating standing. These include:

(1) Jurisdictional reach: When conducting a social cost-benefit analysis, there are often issues relating to jurisdictional impacts. For example, the Queensland government may not be concerned with the impact of a policy on the neighbouring state New South Wales. From the perspective of the Queensland government, the preferences of New South Wales should not be accounted for in a CBA as it is beyond their jurisdictional reach. This creates problems when there are spill-over effects of policies e.g., PCR test requirements to enter into Queensland during December, 2021.

(2) Considerations of future generations: When conducting a CBA there can be impacts that extend beyond the current generation. Usually when selecting the time horizon, we evaluate a project over a set timeline. However, benefits and costs can accrue well into the future. Given the length of time these benefits and costs will accrue over into the future, often when discounted these will have relatively small net benefits. Consequently, these kinds of projects are unlikely to be approved. This is a particular conundrum for environmental policies. For example, climate change policies will have impacts on both current and future generations. However, when considering climate change policies often only the preferences of current generations are accounted for.

(3) Valuation of life: Valuing life is a contentious issue in both health economics and cost-benefit analysis. There are two approaches often used; (1) the value of human capital and (2) the willingness-to-pay for medical inventions. When evaluating the preferences of an adult under these circumstances for inclusion in the CBA there are clear techniques to use. However, we cannot easily account for the preferences of newly born infants. An infant has not developed sufficiently to understand their preferences or make judgements. Furthermore, an infant does not have the resources to pay for their own care. This creates clear issues relating to ethics of valuing a life (discussed in more detail in [Chapter 11](#)).

(4) Unethical behaviours or socially unacceptable preferences: In some instances, people may have preferences that are considered unethical or illegal. If a thief has a preference to steal cars, their willingness-to-pay would be positive to engage in the activity. However, there are people who have a willingness-to-pay to avoid these activities (in the form of law enforcement, car alarms etc.). Therefore, we do not include preferences for criminal activities when evaluating standing. Similarly, the gains from the use of illegal goods or services should not be accounted for (such as illicit drug use or black markets).

(5) Distribution of impacts: Willingness-to-pay (WTP) for a policy will often depend on the distribution of wealth. Traditionally in CBA all groups with standing are assessed using equal weights. This is problematic as the impact of the project may change the WTP. Additionally, it is well known that WTP is heterogeneous across the distribution of wealth. Consequently, it is important to consider who the policy or intervention is directed at.

Consequently, we define those groups with standing in a CBA we include:

- (1) Those who have standing on the basis outlined by the law or ethical standards.
- (2) Those impacted by the project, policy or program regardless of their ability to convey their preferences.

Therefore, when evaluating standing we consider what is right or wrong by societal norms. Note that there is no clear method for identifying those who have standing in a project – it is about capturing those who “should” be accounted for.

## Example 4.1

### Example: How to Identify Standing.

Suppose Queensland Health is considering building a new hospital in Moreton Bay. Along with the benefits and costs associated with building the new hospital, it is expected that there will be a reduced strain on hospitals in and around Brisbane.

- If the residents of Brisbane have standing in the CBA, the benefits of the new hospital should be included in the CBA.
- If the residents of Brisbane do not have standing in the CBA these spill-over benefits should be excluded in the CBA.

In this case, logic determines that the benefits are accruing to both residents of Moreton Bay and Brisbane and therefore both groups should have standing.



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## Perspectives

The perspective component of a CBA is related to the “players” involved in the project. Perspectives can be considered the analytical viewpoint used in the analysis. This is often termed as “accounting stance”, “scope” or “lenses” of analysis depending on the reference material. The assumption so far has been to evaluate a policy, program, or project using a *social* cost-benefit analysis approach taking a perspective predicting and monetising impacts to society as a whole (also known as a societal perspective). However, it is sometimes useful to look at sub-level perspectives in response to narrower interests of those who commission the CBA.

By identifying the perspective an analyst is attempting to determine if the project is financially viable from various viewpoints such as the company, firm, business, government department, government level (local, state, or federal) involved in the investment. For example, a healthcare provider may want to know if the investment in new monitoring machines is worthwhile from a business perspective (investor perspective). Whereas a government may want to compare alternative road projects to identify the best option for the use of resources (government perspective). In either of these decisions, it may be deemed unnecessary, time consuming, or potentially difficult to evaluate the societal impacts.

Different perspectives can lead to different results. In practice, CBA analysts often approach the evaluation of a project based on the client who commissions the CBA. The purpose of this section is to highlight four potential perspectives that can be utilised in the evaluation of an intervention, project, or program.

## Perspectives are different to the concept of standing.

Standing is about whose benefits, and costs need to be accounted. Perspective is the scope of the cost-benefit analysis. It is important to provide explicit context in any CBA report relating to the perspective utilised in the analysis.

### **Key Concept – Standing and Perspective are not the same!**

Standing relates to the stakeholders who are impacted by the policy – those whose benefits and costs matter. To consider standing, we ask “who does the policy, project, or program impact?”

Perspective relates to how we approach the CBA – whose perspective is being used in the evaluation. We consider who we are applying the CBA framework to/ for. This is often termed as “accounting stance”, “scope” or “lenses” of analysis. The goal of social CBA is to implement a social perspective to the evaluation of a policy or intervention.

## **Perspective Approaches**

The literature identifies the best perspective to evaluate the impacts of a policy from an economic approach is to use a “societal perspective” where all costs and benefits are accounted for to improve total economic welfare. However, we consider 4 perspectives for cost-benefit analysis in this course:

- (1) Market Perspective
- (2) Private Firm/Investor Perspective
- (3) Social Perspective
- (4) Distributional/Disaggregated Social Perspective.

This provides well rounded insights into the decision-making from an investor perspective, the social perspective, and the distribution of impacts across stakeholders. By considering all four perspectives we achieve a well-rounded understanding of whether a project is worthwhile or not.

## **Market Perspective**

The market perspective of a cost-benefit analysis is the most basic CBA that can be conducted. The market perspective involves evaluating the policy, project, or program purely based on the market prices of impacts. This is a financial appraisal in the simplest form, emphasising and evaluating only benefits and costs that can be evaluated based on market prices. This perspective ignores who the gains and losses accrue to and does not consider whether market prices represent the true value of goods and services. Market distortions and market failures are assumed away, along with taxes and financing (loans) of a project that would impact the investor’s decision.

## Investor Perspective

The investor or private perspective refers to the party that is engaging in the project.<sup>1</sup> A private firm has the goal of maximising their profit. Therefore, a CBA from the perspective of a firm or business is fundamentally different to a social CBA as the firm is only interested in specific costs and benefits that affect their profitability. The idea of conducting this type of CBA is to understand whether a project is worthwhile from an investor perspective. No private sector company would undertake a unprofitable project. The costs and benefits are those solely related to running the project:

- Costs are outflows of cash from a business which include wages paid to employees, purchases of inputs to produce goods and services, rent paid for buildings, equipment and capital purchases, loan repayments and interest payments, taxes, and other expenses.
- Benefits are inflows of cash to a firm or business in the form of revenue from sales of goods and services, interest from investments and even government subsidies.

Under this perspective, an analyst is treating the program, policy, or project as a private investment. This type of analysis aligns with the application of financial appraisal discussed in [Chapter 1](#).<sup>2</sup>

It is important to note that if a government takes a market or investor perspective as their sole component in their decision-making, the overarching goal is to maximise the use of their own financial resources. Adopting this limited perspective is intuitively against the role of government. At various levels (local, state, or federal), governments do not exist to maximise the amount of money in the treasury. Instead, governments exist to provide goods and services that are not provided by the private sector such as streetlights, roads, health care, etc. Consequently, from a government policymaker perspective it does not make sense to limit a CBA to the market or investor perspective as the goals of the CBA are fundamentally different.



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1. in the context that the government is the investor, this may be called the government perspective.

2. The public sector may also be interested if a project would run at a cost at the “department” level.

## Social Perspective

The social perspective is the basis of social cost-benefit analysis. In a social cost-benefit analysis, all impacts borne by the project must be included in the analysis. This includes any social impacts, environmental impacts and corrections for market failures or distortions. The goal is to evaluate an intervention from the viewpoint of society to determine whether the project, program, or policy is beneficial to society or the economy as a whole. This is done at an aggregate perspective level. For example, if the project is for the development of a new local road in Brisbane, intangible benefits including time saved, safety improvements, as well as environmental impacts must be accounted for in the analysis. These values would need to be predicted and monetised as part of the process covered in the analysis. Shadow prices are used to reflect the true value of goods and services in a social perspective.



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## Distributional Social Perspective

Social cost-benefit analysis at the aggregate level ignores distributional level effects. The *distributional* social perspective is the process of disaggregating the results of the social cost-benefit analysis such that the benefits and costs can be attributed to various groups within society. This is often considered crucial by policymakers as the costs and benefits that accrue to the public may not accrue to groups evenly. Evaluation of these impacts is important to ensure that there are no unintended consequences from conducting an intervention or project. Additionally, policymakers and other stakeholders are likely to be interested in the impacts that affect the population even if decisions are driven by other factors (political or social), as it provides a better understanding of societal issues and social preferences (Robinson et.al, 2019. p.62).

More specifically, evaluating the impacts across all stakeholders allows clear identification of the Kaldor Hicks criterion which is described in detail in [Chapter 6](#). At this point, we can define the Kaldor Hicks compensation criterion – a policy is more efficient as long as there is a net gain to society as this enables compensation between winners and losers of a project, resulting in a net gain to society. Therefore, the social perspective to CBA allows for governments to identify whether the process of redistribution is required as part of the compensation process. From a government approach to CBA, it is important to ensure decision-makers are not creating policies where the rich benefit at the cost of the poor. Therefore, if equity is important as part of the evaluation criteria of the policy or project, we need to evaluate the impacts on a disaggregated level.

To find the distributional impact, we identify rents accruing to stakeholders in terms of their gains or losses. We can then use this information to determine whether there are any undesirable consequences of



the project or intervention. More details will be discussed in [Chapter 9](#) once a foundation level knowledge has been developed.

## Example 4.2

### **Example: The reason for multiple perspectives.**

Suppose a CBA regarding the building of a road by-pass is being conducted by the Transportation and Roads department. If the department takes an investor perspective, only the inflows and outflows of monetary value to and from the government department will be accounted for in evaluating the project. Consequently, the goals of building a by-pass would not be effectively evaluated – such as increased safety and reduced travel time for residents.

If the CBA is done from the social perspective the benefits and costs to the entire city, residents and the government will be captured in the CBA. The social CBA can also extend to capture spill-over benefits to neighbouring cities.

## Revision



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## Summary of Learning Objectives

1. Standing involves identifying whose benefits and costs matter when evaluating a policy,

program, or project.

2. There is no “hard and fast rule” on how to identify standing. There are many challenges that can impede the identification of which preferences to account for.
3. There are four perspectives we use for CBA. The market and investor methods are financial appraisal methods. The social perspective captures all tangible and intangible impacts borne by society on an aggregate level and the distributional perspective allocates the social impacts to subgroups affected by a policy, project, or program.

## References

Robinson, L. A., Hammitt, J. K., Cecchini, M., Chalkidou, K., Claxton, K., Cropper, M., ... & Wong, B. (2019). Reference case guidelines for benefit-cost analysis in global health and development. Retrieved from [https://papers.ssrn.com/sol3/papers.cfm?abstract\\_id=4015886](https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4015886)

Whittington, D., & MacRae Jr, D. (1986). The issue of standing in cost-benefit analysis. *Journal of Policy Analysis and Management*, 5(4), 665-682.

# CHAPTER 5: MARKET AND INVESTOR ANALYSIS

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## Learning Objectives

After completing this chapter, students should be able to:

1. Evaluate and create a market CBA.
2. Use incremental analysis to select between projects.
3. Compare and contrast sunk costs and working capital in project evaluation.
4. Implement loans, interest rates, depreciation, and taxes in financial appraisals.
5. Develop a CBA from the investor perspective.

*Reminder: Net social benefit will be different from net private benefits if market failure exists in the project or program being evaluated. At this stage we assume that all benefits and costs can be accounted for, and market failure does not occur in the scenarios we analyse to keep concepts simplified. We will introduce market failures into our CBA analysis in Parts [3](#) and [4](#).*

## Market Perspective Basics

The market CBA utilises market prices to estimate the costs and benefits in financial terms to the economy. It does not correct for any market failures and ignores taxes, financing, and interest repayments. Put simply, the market perspective will account for tangible market transactions in the form of benefits and costs at market price regardless of who those benefits and costs accrue to. Usually a market analysis will include: (1) any initial investment costs to implement or start a project including working capital, (2) any salvage/

horizon values and (3) any ongoing benefits and costs that accrue over the life of the project – all measured using market prices.

## Example 5.1

### Example: Market Analysis

Company X is a printing business. Currently the company only has traditional paper printers. Due to current demand in the market, Company X is considering purchasing a 3D printer to provide the additional service to customers. The 3D printer will cost the company \$5,000 as the initial investment and will require maintenance at a cost of \$350 per year over the expected life of 5 years. The expected benefit from the printer is an additional income of \$1,500 per year at the current year 0 market price. At the end of the 5-year period, Company X would need to salvage the 3D printer for 10% of the initial cost. Conducting a market analysis, we would get the following table:

**Table 5.1: Company X's 3D Printer – Market Perspective**

Year	0	1	2	3	4	5
<b>Benefit</b>		1500	1500	1500	1500	1500
<b>Initial Cost</b>	-5,000					
<b>Ongoing Cost</b>		-350	-350	-350	-350	-350
<b>Salvage Value</b>						500
<b>Net Benefit</b>	-5000	1150	1150	1150	1150	1650
<b>Net Present Value</b>	<b>\$370.66</b>					

The status quo in this case is *to not purchase the 3D printer* and continue to only use the traditional printers the business currently owns. The 3D printer should only be purchased if the net present value is greater than zero. If we assume the correct discount rate for this project on behalf of Company X is 5%, the net present value of the project is \$370.66. Consequently, the purchase of the printer should be undertaken.

If you would like to replicate the result for this example, please download this spreadsheet:

[Example5.1](#)

The result of the market perspective is exactly what we have discussed up to this point in the course. We want to build on this foundation level understanding to further develop the CBA.

## Incremental/Marginal Analysis

When considering some cost-benefit analysis projects, it is important to understand that we may want to look at the *marginal* gains from additional projects as part of the analysis. Consequently, incremental analysis in CBA is also sometimes referred to as marginal analysis. This method is specifically useful when a project is *required* to be undertaken in some form. For example, if a policymaker requires an upgrade to a traffic light road intersection. However, the government may also consider the addition of improved footpaths. To evaluate whether the additional gains from undertaking the upgrade to the footpaths and traffic lights combined, we can evaluate the incremental net benefit of the project, treating the initial investment project as the base case scenario.<sup>1</sup>

It is also important to note that incremental investment analysis is similar to finding the crossover rate (from [Chapter 2](#)). However, with the crossover rate, the comparison is between two different projects. When looking at the marginal analysis, the focus is on the additional investment or extension of the project under consideration.

This method of incremental analysis is often used in environmental projects and healthcare projects where interventions are required by government. The government seeks to evaluate whether the marginal gain from the additional improvements or expenditures is better than the base case project.

### Example 5.2

#### Example: Incremental Investment.

Suppose that Company X is required to purchase at least one 3D printer as part of the terms of a contract with a customer. In this case, the base case will be the purchase of a single printer. To determine if it is worthwhile to purchase two 3D printers instead of just one, we can evaluate the incremental gain from having two printers compared to purchasing the required single printer.

Given the net benefits outlined in Table [5.2](#), we can calculate the incremental benefits by subtracting (1) from (2).

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1. There is no status quo comparison when using incremental analysis, we compare against the base case scenario.

**Table 5.2: Incremental Analysis of 3D Printer Purchasing Decision**

Year	0	1	2	3	4	5
(1) Net Benefit (one printer – base case)	-5,000	1,150	1,150	1,150	1,150	1,650
(2) Net Benefit (two printers)	-10,000	2,200	2,200	2,200	2,200	3,200
(3) Incremental Net Benefit	-5,000	1,050	1,050	1,050	1,050	1,550

After calculating the incremental net benefit in (3), we can then calculate the net present value or the internal rate of return for this stream of benefits. Assuming a 5% discount rate the incremental NPV is -\$62.29 and the IRR is 4.57%.

To attempt this example yourself, download the spreadsheet found here: [Example5\\_2](#)

When conducting incremental analysis remember that you subtract the base case scenario from the alternative that is being considered i.e., in Example 5.2 above, we subtract row 1 from row 2 as row 1 is the base case scenario. The difference is summarised in the incremental net benefit stream in row 3.



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## Working Capital

**Working capital** is inventories needed to be able to produce a good or service as part of a project. It is considered the operating liquidity of a project and captures assets, cash, accounts receivables, inventories, and materials. Usually in the case of cost-benefit analysis, we include working capital in a CBA when a project has initial inventory investment requirements. Working capital often starts in Year 1 when production of the good or service begins, and inventories are purchased. Working capital can then be increased or decreased throughout the life of the projects. At the end of the project, working capital is reversed out of the project as a benefit. *Consequently, all changes in working capital must be accounted for in the costing of the project.* When purchasing working capital, we treat the cashflow as a cost (negative) and when we sell working capital, we treat it as a benefit (positive).

## Example 5.3

### Example: Working Capital

Returning to the example of Company X from Example 5.1.

Company X requires working capital in the form of filaments for the 3D printer. In year 1, the company purchases \$50 worth of filaments. In year 3, Company X decides to purchase an additional \$50 worth of filaments for their inventories increasing the total working capital to \$100. Working capital is then sold back at the end of the project in year 5.

Table 5.3 shows the stock of working capital over the 5-year period of the project. However, when accounting for working capital in a CBA, we only consider the changes in working capital as represented in Table 5.3. These changes in working capital are treated as an outflow when the working capital is purchased (negative) and an inflow (positive) when the project ends. Consequently, the balance of the change in working capital over the life of the project should be zero i.e. the sum of the change in working capital row must equal zero.

**Table 5.3: Working Capital and the Change in Working Capital**

Year	0	1	2	3	4	5
<b>Working Capital</b>		50	50	100	100	0
<b>Change in Working Capital</b>		-50		-50		100

Table 5.4 shows how to incorporate the change in working capital in the cost-benefit analysis, leveraging off the information from Example 5.1. The addition of working capital, the net benefit changes. Assuming a 5% discount rate, we can see that the NPV of the project has decreased slightly, taking into account the timing of the working capital investments over the life of the project.



Table 5.4: Incorporating the Change in Working Capital

Year	0	1	2	3	4	5
Benefit		1,500	1,500	1,500	1,500	1,500
Initial Cost	-5,000					
Working Capital ( $\Delta$ )		-50		-50		100
Ongoing Cost		-350	-350	-350	-350	-350
Salvage Value						500
Net Benefit	-5,000	1,100	1,150	1,100	1,150	1,750
Net Present Value	\$358.20					

To replicate this example, you can download this spreadsheet: [Example5\\_3](#)

### Key Concept – Working Capital

**Working capital** is inventories needed to be able to produce a good or service as part of a project. *Changes* in working capital should be included in a cost-benefit analysis.



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## Sunk Costs in Cost-Benefit Analysis

Most economists are aware of the concept of **sunk costs**. Sunk costs are costs that have already been incurred and cannot be recovered. In general, sunk costs are excluded from any future decision-making – as we cannot go back in time and change the past. Decision-making is focused on choices related to current and future projects or policies. Consequently, in CBA we exclude any sunk costs that were incurred before the evaluation of the project as these costs are irrelevant to any future decisions.

Furthermore, sunk costs are not included in CBA as there is no opportunity cost involved. By including

sunk costs in the evaluation of a project or policy in CBA, we require a much higher return on the project to counteract the increased costs. Only present and future costs or benefits are assessed in a CBA framework.<sup>2</sup>

For example, suppose a government had already purchased some unused land for \$10 million, 10 years ago. When considering using the land in the present year for a project, the government would not include the \$10 million cost of the past purchase of the land. Only the opportunity cost of the land would be accounted for in the CBA.



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## Private Firm (Investor) Perspective

When conducting a CBA from a private perspective we are considering the project or policy from the point of view of the investor who will implement it. Therefore, the investor can be a private firm (private sector) or the government (public sector). To evaluate a project from the perspective of the investor, we are evaluating the profitability of the project – a form of financial appraisal.<sup>3</sup> Consequently, we need to account for loans (principal and interest), taxes, and depreciation. The way we deal with these issues is highlighted in the examples that follow.

## Debt Financing

*Note: Remember that the rate of interest paid on a loan is not the same as the discount rate in cost-benefit analysis. The interest rate paid on loans is often referred to as the cost of capital or cost of borrowing.*

Loan repayments only matter from the perspective of private firms or investors! It is not appropriate for any debt financing to be accounted for in a social cost-benefit analysis perspective. In addition to this, we do not treat the implementation of the loan as a “cost” to the project. We include it as a separate cashflow component in the project. However, to have a full understanding of CBA it is important we understand financial appraisal basics, including why investors may take out loans for projects.

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2. For ex-ante CBA. However, ex-post CBA should also exclude any sunk costs that occurred before the start of a project.

3. This is often considered necessary if we wish to identify the distributional social impacts of a project. This analysis allows for the identification of the benefits that directly accrue to an investor. The remaining benefits and costs can then be identified and allocated to the various stakeholders with standing in the project.

Financing has two components: (1) the principal of which is the amount borrowed from the bank or lender, and (2) the interest is the cost charged by the bank or lender to you to borrow this money. This is important for us to note as interest on debt is tax deductible which will be relevant for determining after tax profits.

To implement loans in a CBA, there are two methods in our spreadsheet. The preferred approach depends on the goal of the analysis.

(1) Method 1 implements the loan from the view of the private firm (the borrower), where the loan is treated as an inflow to the investor (positive) and all repayments are an outflow (negative).

(2) Method 2 implements the loan from the bank perspective. When implementing the loan from the perspective of the bank, the loan is treated as an outflow to the investor (negative) and all repayments are an inflow. *This method is preferred if you want to calculate the internal rate of return on debt.*

The remaining net benefit after accounting for loan repayments is the “net private benefit” or equity on investment. Equity is the gain to the private investor. Consequently, the goal of the investor perspective is to determine the return to the private firm via the equity received from the project.



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## Implementing Debt Financing in Excel

The functions to implement the loans in Excel are outlined in Example [5.4](#) below. Note the following information on the Excel functions used for loans:

=PMT() function calculates the annuity of the loan – i.e., This function calculates the payment for a loan based on constant payments and a constant interest rate for the life of the loan (i.e., an annuity repayment). This value is the same for all periods accounted for in the project. The repayments can be yearly, quarterly, monthly, etc.

=PPMT() function calculates the amount of principal that contributes to the loan repayment assuming the loan is paid as an equal annuity for the life of the loan.

=IPMT() function calculates the amount of interest that contributes to the loan repayment assuming the loan is paid as an equal annuity for the life of the loan.

## Example 5.4

Following from Example 5.1. Assume that Company X requires a loan for the 3D printer worth \$2,500 at a 3.5% cost of borrowing and the appropriate discount rate is 5%. Starting with the Net Benefit from the market analysis (the last row of Table 5.1), it is possible to incorporate the loan using either of the following two approaches as shown below:

### Approach (1) – borrower’s view of debt

In this instance we treat the initial loan as a positive inflow and the repayments as a negative outflow. Calculating the interest on the loan will give the following:

Table 5.5: Borrower’s view of debt

Year	0	1	2	3	4	5
Net Benefit (Market)	-5,000	1,150	1,150	1,150	1,150	1,650
Loan (Principal + Interest)	2,500	-554	-554	-554	-554	-554
Net Private Benefit (Equity)	-2,500	596	596	596	596	1,096
Net Present Value (Private)	\$473.42					

To implement this in Excel, use the =PMT() function to calculate the principal and interest for row 9 as shown in Figures 5.1 and 5.2. Note that the repayments on the loan are equal in size to the value of \$554. This is because the loan is being paid back per year in equal instalments (an annuity).

	A	B	C	D	E	F	G	H	I	J	K	L
1												
2		Discount Rate	5%									
3		Loan	2,500									
4		Interest on Loan	3.50%									
5		Loan Life	5									
6												
7		Year	0	1	2	3	4	5				
8		Net Benefit (Market)	-5,000	1,150	1,150	1,150	1,150	1,650				
9		Loan (Principal + Interest)	2,500	-554	-554	-554	-554	-554	=PMT(rate, total loan life, present value)			
10		Net Private Benefit (Equity)	-2,500	596	596	596	596	1,096				
11		Net Present Value (Private)	\$473.42									

Figure 5.1:  
Approach 1  
Borrower’s View  
of Debt and the  
PMT Calculation  
Command

	A	B	C	D	E	F	G	H	I	J	K	L
1												
2		Discount Rate	5%									
3		Loan	2,500									
4		Interest on Loan	3.50%									
5		Loan Life	5									
6												
7		Year	0	1	2	3	4	5				
8		Net Benefit (Market)	-5,000	1,150	1,150	1,150	1,150	1,650				
9		Loan (Principal + Interest)	2,500	-554	-554	-554	-554	=PMT(C4,C5,C9)				
10		Net Private Benefit (Equity)	-2,500	596	596	596	596	1,096	=PMT(rate, total loan life, present value)			
11		Net Present Value (Private)	\$473.42									
12												

Figure 5.2: PMT Implementation Demonstration

As the loan uses the same formula you can lock the formula cells using the F4 button in windows (on Mac use function + command + T) as shown in Figure 5.3 below. The “\$” in front of the letters locks the column and the “\$” in front of the number locks the row. This way you can copy the formula across for all years in the project. Remember to only lock cells where appropriate.

	A	B	C	D	E	F	G	H	I	J	K	L
1												
2		Discount Rate	5%									
3		Loan	2,500									
4		Interest on Loan	3.50%									
5		Loan Life	5									
6												
7		Year	0	1	2	3	4	5				
8		Net Benefit (Market)	-5,000	1,150	1,150	1,150	1,150	1,650				
9		Loan (Principal + Interest)	2,500	-554	-554	-554	-554	=PMT(\$C\$4,\$C\$5,\$C\$9)				
10		Net Private Benefit (Equity)	-2,500	596	596	596	596	1,096	=PMT(rate, total loan life, present value)			
11		Net Present Value (Private)	\$473.42									

Figure 5.3: PMT Calculation Demonstration with Locked Cells Using \$

### Approach (2) – bank/lender view of debt

In the instance where we approach the loan from the perspective of the lender we still use the =PMT() function to calculate the principal and interest for row 9 as shown in Figures 5.1 and 5.2, however we just invert the signs with a negative “-” in front of the =PMT(). This is highlighted in purple in Figure 5.4 below.

	A	B	C	D	E	F	G	H
1								
2		Discount Rate	5%					
3		Loan	2,500					
4		Interest on Loan	3.50%					
5		Loan Life	5					
6								
7		Year	0	1	2	3	4	5
8		Net Benefit (Market)	-5,000	1,150	1,150	1,150	1,150	1,650
9		Loan (Principal + Interest)	-2,500	554	554	554	554	554
10		Net Private Benefit (Equity)	-2,500	596	596	596	596	1,096
11		Net Present Value (Private)	\$473.42					
12								

Figure 5.4: Approach Two – Banker/Lender View of Cash Flows for the Loan

In both Approach (1) and Approach (2) we achieved the same Net Private Benefit. In addition to this it is clear that the Net Benefit on the Market is equal to the Debt Financing and Net Private Benefit. i.e. row 9 and 10 sum to row 8 in the analysis.

To replicate this result, you can download the spreadsheet here: [Example5\\_4](#)

It is also worthwhile to note that the total loan repayment is equal to the sum of the principal and interest payments (PPMT and IPMT solutions sum to the PMT solution). This makes it easier to check you have implemented the functions correctly in Excel. Take caution with negative and positive numbers in the cells for this analysis – think of the logic related to how we will need to deal with interest payments as a tax deduction as this will be important later for determining after tax profit (see [this section](#) on interest, depreciation, and taxes liable).

One important thing to note is that often it is useful to separate out the principal and interest repayments on a loan. This is because for an investor the interest repayment can be subtracted from the before tax profits. An illustration of how to separate these out is show in Example 5.5 below.

## Example 5.5

### Example: Separating Principal and Interest

Following from the Example above, separating the principal and interest is easy. In Excel =PPMT() function will calculate the principal and the =IPMT() function will calculate the interest. Figure 5.5 and 5.6 demonstrate an example.

	A	B	C	D	E	F	G	H	I	J	K	L
1												
2		Discount Rate	5%									
3		Loan	2,500									
4		Interest on Loan	3.50%									
5		Loan Life	5									
6												
7		Year	0	1	2	3	4	5				
8		Net Benefit (Market)	-5,000	1,150	1,150	1,150	1,150	1,650				
9		Loan (Principal)	-2,500	466	483	499	517	535	=PPMT(rate, year, total loan life, PV)			
10		Loan (Interest)		88	71	54	37	19	=IPMT(rate, year, total loan life, PV)			
11		Net Private Benefit (Equity Before Tax)	-2,500	596	596	596	596	1,096				
12		Net Present Value (Private Before Tax)	\$473.42									
13												

Figure 5.5:  
Separating  
Principal and  
Interest Payments  
of the Loan

Note that the “year” component should not be cell locked as it should vary over the life of the loan. i.e. in year 1 =PPMT(\$C\$4,**D7**,\$C\$5,\$C\$9) and in year 5 =PPMT(\$C\$4,**H7**,\$C\$5,\$C\$9). More specifically, the red cell in the figure below will move between years 1-5. The remaining cells are constant values from the variable section of the spreadsheet. This way you can drag your formula across.

	A	B	C	D	E	F	G	H
1								
2		Discount Rate	5%					
3		Loan	2,500					
4		Interest on Loan	3.50%					
5		Loan Life	5					
6								
7		Year	0	1	2	3	4	5
8		Net Benefit (Market)	-5,000	1,150	1,150	1,150	1,150	1,650
9		Loan (Principal)	-2,500	466	483 =PPMT(\$C\$4,H7,\$C\$5,\$C\$9)			
10		Loan (Interest)		88	71	54	37	19
11		Net Private Benefit (Equity Before Tax)	-2,500	596	596	596	596	1,096
12		Net Present Value (Private Before Tax)	\$473.42					
13								

Figure 5.6:  
Example of  
implementing  
=PPMT function in  
Excel for Year 5.

The =IPMT() function follows the same process as the PPMT function. To check if you have completed it correctly, you can add the principal (=PPMT) and interest (=IPMT) together and it should equate to the annuity of the loan found using the =PMT function.

To replicate this result, you can download the spreadsheet here: [Example5\\_5](#)

Example 5.5 also illustrates the relationship between the principal and the interest. Specifically, interest is charged based on the remaining balance of the loan. As each repayment is made, the balance of the loan decreases and consequently, the proportion of principal repaid in each subsequent repayment increases. This is observed by the increasing values of the principal component and decreasing values of the interest component on the loan. However, if you add the principal and interest in each column, it will equate to the total annuity found by using the =PMT() function.



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## Debt Financing, Gearing and the IRR on Equity

As illustrated in Example 5.4, we observe the following result:

- (1) *Market Net Benefit = Debt Finance + Private Equity.*

Comparing the NPV's for Example 5.1 and Example 5.4 we can see that the NPV on the market is \$370.66 and the NPV for the Printing Company X (the private investor) is \$473.42. From the private investor perspective, the loan improves the profitability of the project. *This begs the question – why not just take out many loans for all projects?*

To understand this more effectively it is a good idea to investigate the internal rate of return on debt

and equity. However, it is important to note that the internal rate of return on equity is not the difference between of the IRR on debt and the IRR on the market (i.e.  $IRR_{Market} \neq IRR_{Debt} + IRR_{Equity}$ ). To calculate the IRR on equity we need to take into account the proportion of debt and equity involved in the project. i.e., the debt-equity ratio. We then input these percentages into the following formula:

$$(2) \quad \begin{aligned} IRR \text{ on Market} = & \text{proportion of debt} \times IRR_{Debt} \\ & + \text{proportion of equity} \times IRR_{Equity} \end{aligned}$$

## Example 5.6

### Example: Debt to Equity Ratio and Gearing

To calculate the IRR on Equity, we can calculate the IRR on the market and on the debt by using the IRR formula. To illustrate this, we can use Example 5.4. Again we assume a 5% discount rate.

Firstly, we want to calculate the IRR on debt, we must use Approach (2) for the loan to find the IRR. Otherwise, you will calculate the incorrect IRR as IRR as a function in Excel requires an outflow as the first cell in the function, followed by inflows and /or outflows i.e. the first cell must be negative when using the =IRR() function. Calculating the IRR for the market and the IRR on debt using the =IRR() function in Excel, as demonstrated in Figure 5.7.

	A	B	C	D	E	F	G	H	I
1									
2		Discount Rate	5%						
3		Loan	2,500						
4		Interest on Loan	3.50%						
5		Loan Life	5						
6									
7		Year	0	1	2	3	4	5	IRR
8		Net Benefit (Market)	-5,000	1,150	1,150	1,150	1,150	1,650	=IRR(C8:H8)
9		Loan (Principal + Interest)	-2,500	554	554	554	554	554	3.50%
10		Net Private Benefit (Equity)	-2,500	596	596	596	596	1,096	
11		Net Present Value (Private)	\$473.42						
12									

Figure 5.7:  
Calculating the IRR  
on the Market  
Perspective

The result of this calculation is provided in Table 5.6 below:



**Table 5.6: Internal Rate of Return on the Market and Debt**

Year	0	1	2	3	4	5	IRR
<b>Net Benefit (Market)</b>	-5,000	1,150	1,150	1,150	1,150	1,650	<b>7.51%</b>
<b>Loan (Principal + Interest)</b>	-2,500	554	554	554	554	554	<b>3.50%</b>
<b>Net Private Benefit (Equity)</b>	-2,500	596	596	596	596	1,096	
<b>Net Present Value (Private)</b>	\$473.42						

Once we have the IRR for the Market (7.51%) and the IRR on Debt (3.50%). As observed in this example, the debt-to-equity ratio is 50:50. There is a loan worth \$2,500 and the remainder of the investment in capital stock is Company X's equity of \$2,500. We can apply the formula from equation (2).

$$IRR \text{ on Market} = \text{prop. of debt} \times IRR \text{ Debt} + \text{prop of equity} \times IRR \text{ Equity}$$

$$7.51\% = 0.5 \times 3.50 + 0.5 \times IRR \text{ Equity}$$

$$IRR \text{ Equity} = 11.51\%$$

As can be seen from the example the  $IRR \text{ on Market} \neq IRR \text{ Debt} + IRR \text{ Equity}$ .

To replicate this example you can download this spreadsheet: [Example5\\_6](#)

As can be seen from the example the  $IRR \text{ on Market} \neq IRR \text{ Debt} + IRR \text{ Equity}$ . Changing the ratio of debt-to-equity will change the result of the internal rate of return on equity and therefore the profitability of the project to the investor. In fact, as the proportion of debt increases, the IRR on equity will increase. For example, if we have a market IRR of 8% and IRR on debt of 5%, if the debt-equity ratio is 50:50, then the IRR on equity would be 11%. If the IRRs for the market and debt remained the same but the debt-to-equity ratio increased to 80:20, then the IRR on equity would be 20%.

From this example we can see that it is better for a company to take out a loan when investing in a project. However, we should note that if the debt-to-equity ratio is too large it would be unlikely to find a bank to lend money as banks will not lend to projects with very high levels of debt. Banks do not lend at high debt-to-equity ratios as it would be considered risky.

The IRR on equity is important. However, it should not be the driver of the decision in CBA as it does not capture the social aspects of cost-benefit analysis. Additionally, the IRR on equity can make a good project look like a bad investment and a bad project look like a good investment. This highlights the role of gearing in CBA – IRR is misleading as a measure of net benefits.

## Depreciation and Tax Liability

*Depreciation and taxation laws vary from country to country. This section provides a basic approach to dealing with depreciation in the context of an investor perspective. It is important if you are applying these concepts in the real world to consult the relevant taxation services.*

The initial investment cost for an asset captures the value of the investment. Including depreciation in a CBA as a cost would result in double counting the value of the initial investment. This is because depreciation is already accounted for in the initial investment, so adding it again as a cost would mean counting it twice. Consequently, depreciation is not included in the market, social or disaggregated cost-benefit analyses.

However, depreciation in the financial appraisal space is essential as a bookkeeping mechanism. Including depreciation in the evaluation of the investor perspective amounts to setting aside part of the project's income to finance equivalent capital expenditure in the future. This is a useful approach to project evaluation when you are expecting to replace large amounts of equipment or capital when rolling projects over. Additionally, from a private perspective we may need to consider depreciation in relation to profits as part of the calculation of taxable income. In this instance we can treat depreciation as an outflow that reduces taxable income.

### Key Concept – Depreciation in Investor CBA

Depreciation is about spreading the cost of an asset over its useful life and matching expenses with revenue. It is a financial mechanism and therefore should only be accounted for in the investor CBA. Always use straight line depreciation.

Depreciation should never be used in the market or social perspectives.

When calculating depreciation in CBA, the straight-line method is used. To keep it simple when using straight line depreciation, we take the value of the asset and divide it by the asset's useful life.<sup>4</sup> Depreciation is then subtracted from the firms before tax profits. Specifically, we calculate this in two steps:

(1)  $Profit_{before} = Revenue - Operating\ Cost - Depreciation - Interest\ Repayments$ ,  
then calculate

(2)  $Equity\ after\ tax = market\ net\ benefit - tax\ liable$

---

4. Depending on the context and standards of relevant department or companies it may be necessary to subtract the salvage value from the value of the asset might be required when taking a financial analysis approach. In CBA we often do not incorporate this method in the instance the salvage value may be negative instead of positive. By taking the approach of salvage + full depreciation we end with a more conservative estimate of the NPV.

### Example 5.7

Returning to Example 5.1, Company X is considering purchasing a 3D printer to provide the additional service to customers. The 3D printer will cost the company \$5,000 as the initial investment and will require maintenance at a cost of \$350 per year over the expected life of 5 years. The expected benefit from the printer is an additional income of \$1,500 per year at the current year 0 market price. At the end of the 5-year period, Company X would need to salvage the 3D printer for 10% of the initial cost. Assume a 5% discount rate.

Assuming *straight line depreciation*, and a 25% tax rate – the private perspective can be calculated by taking the market perspective, subtracting the taxes paid on profits. Taxes paid on profits must take into account depreciation and interest paid on loans. In this case we have assumed there is no loan and only depreciation needs to be accounted for. The straight-line depreciation value would be:

$$\begin{aligned} \text{Depreciation} &= \frac{\$5,000}{5 \text{ years}} \\ &= \$1,000 \end{aligned}$$

To calculate before tax profits for each year we take the revenue (1,500) and subtract the ongoing operating cost (350), and the depreciation (1,000). This leave a before tax profit of \$150 as shown in Table 5.7. With a 25% tax rate, the tax liable is \$37.50. Note that taxes can be inputted as a negative value or a positive value in Excel. But to find the after tax for each year the taxes are *subtracted* from the Net Benefit (Market).

**Table 5.7: Accounting for Depreciation in the Private Perspective**

Year	0	1	2	3	4	5
<b>Benefit</b>		1,500	1,500	1,500	1,500	1,500
<b>Initial Cost</b>	-5,000					
<b>Ongoing Cost</b>		-350	-350	-350	-350	-350
<b>Salvage Value</b>						500
<b>Net Benefit (Market)</b>	-5,000	1,150	1,150	1,150	1,150	1,650
<b>(a) Profit</b>						
<b>Revenue</b>		1,500	1,500	1,500	1,500	1,500
<b>Operating Cost</b>		-350	-350	-350	-350	-350
<b>Depreciation</b>		-1,000	-1,000	-1,000	-1,000	-1,000
<b>Profit Before Tax</b>		150	150	150	150	150
<b>Taxes</b>		37.50	37.50	37.50	37.50	37.50
<b>(b) Equity After Tax</b>						
<b>Equity (After Tax)</b>	-5,000	1,113	1,113	1,113	1,113	1,613
<b>NPV (after tax)</b>	\$ 208.31					

To replicate this example, you can download the spreadsheet found here: [Example5\\_7](#)

## Combining Debt Financing & Depreciation in the Investor Perspective

The last stage of the investor perspective is to combine all elements discussed in this chapter. i.e., calculate the market perspective including debt financing and depreciation. Both interest and depreciation can be subtracted from the investors profit before calculating the tax liable. This is illustrated in Example 5.8 below.

### Example 5.8

#### Example: Including Both Debt Financing and Depreciation

Assume we are considering Company X's options to take a loan and depreciate the new 3D printer. The 3D printer will cost the company \$5,000 as the initial investment and will require maintenance at a cost of \$350 per year over the expected life of 5 years. The expected benefit from the printer is an additional income of \$1,500 per year at the current year 0 market price. At the end of the 5-year period, Company X would need to salvage the 3D printer for 10% of the initial cost.

In addition to this, Company X would like to take a loan worth \$2,500 to help finance the project. The interest rate on the loan will be 3.5% and the loan life will be equivalent to the life of the project (5 years). Company X would also depreciate the 3D printer over the 5 years using straight line depreciation.

We have the following information in Table 5.8:

**Table 5.8: Variable Inputs for Company X**

<b>Discount Rate</b>	5%	<b>Benefit</b>	1,500
<b>Loan</b>	2,500	<b>Initial Cost</b>	5,000
<b>Interest on Loan</b>	3.50%	<b>Ongoing Cost</b>	350
<b>Loan Life</b>	5	<b>Salvage</b>	10%
		<b>Tax</b>	25%

Step 1 is to calculate the market perspective first using the annual benefit, initial cost, ongoing cost and salvage value as shown in part (a) in Table 5.9 below.

Step 2 is to calculate the Net Private Benefit after loan repayments in part (b) of the table. Note that we have separated out the principal and interest to make it easier to account for the interest.

Step 3 is to calculate the before tax profit by subtracting operating costs, depreciation, and interest repayments from the revenue (shown in part (c)). We then multiply this profit by the tax rate in the last row of part (c).

Finally, taking the difference between the Net Private Benefit and the taxes liable will provide the equity to the firm. Once this is found, we can apply the =NPV() function in Excel to find the NPV to the private investor, in this case Company X.

**Table 5.9: Full Market and Private Perspectives for Company X's 3D Printer Project**

Year	0	1	2	3	4	5
(a)						
<b>Benefit</b>		1,500	1,500	1,500	1,500	1,500
<b>Initial Cost</b>	-5,000					
<b>Ongoing Cost</b>		-350	-350	-350	-350	-350
<b>Salvage Value</b>						500
<b>Net Benefit (Market)</b>	-5,000	1,150	1,150	1,150	1,150	1,650
(b)						
<b>Loan (Principal)</b>	2,500	-466	-483	-499	-517	-535
<b>Loan (Interest)</b>		-88	-71	-54	-37	-19
<b>Net Private Benefit (Equity)</b>	-2,500	596	596	596	596	1,096
(c)						
<b>Revenue</b>		1,500	1,500	1,500	1,500	1,500
<b>Operating Cost</b>		-350	-350	-350	-350	-350
<b>Depreciation</b>		-1,000	-1,000	-1,000	-1,000	-1,000
<b>Interest</b>		-88	-71	-54	-37	-19
<b>Profit Before Tax</b>		62.50	78.82	95.71	113.18	131.28
<b>Taxes</b>		15.63	19.70	23.93	28.30	32.82
(d)						
<b>Equity (After Tax)</b>	-2,500	581	577	572	568	1,063
<b>NPV@5% (after tax)</b>	<b>\$ 371.00</b>					

As can be seen, after accounting for salvage, depreciation, debt financing, and taxes liable the NPV of the project is positive. Therefore, Company X should undertake this project and purchase the 3D printer using a financing option.

To replicate this example, you can download the spreadsheet found here: [Example5\\_8](#)



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## Timing of Debt Repayments

When we covered compounding in [Chapter 2](#) we assumed that each period was compounded yearly. However, it is important to note that for debt financing interest may be compounded daily, monthly, quarterly, or yearly depending on the terms agreed to by the bank. Based on this, adjustments may need to be made to the interest rates used to ensure that the interest rate appropriately reflects the timing of benefits and costs.

## Effective Annual Interest Rates

Some loans have a monthly rate and need to be converted to annual rates. To do this we can calculate the effective annual interest rate, and subsequently use the effective annual interest rate in the analysis. To calculate the effective annual interest rate, we use the following formula:

$$(3) \quad EAR = \left(1 + \frac{i}{n}\right)^n - 1$$

where:

$EAR$  = Effective Annual Interest Rate.

$i$  = interest rate (this can be daily, bi-annually, quarterly, monthly etc.)

$n$  = number of compounding periods in a year based on the interest rate period.

The equation above indicates that the effective annual interest rate will always be higher than the stated rate if there is more than one compounding period. This is illustrated in [Example 5.9](#) below. Additionally, all things held constant – the more compounding periods the higher the EAR.

### Example 5.9

#### Example: Comparing Interest Rates

Suppose a company is considering a loan. There are two options under consideration and the firm would like to identify which one to select.

- (a) interest rate is 14% compounded quarterly.
- (b) interest rate of 15% compounded annually.

To compare the two interest rates, we need to convert option (a) to an equivalent annual interest rate as follows:

$$\begin{aligned} EAR &= \left(1 + \frac{0.14}{4}\right)^4 - 1 \\ &= (1.035)^4 - 1 \\ &= 14.75\% \end{aligned}$$

Comparing the options, option (a) has an annual interest rate of 14.75% and option (b) has an annual rate of 15%. Consequently, the firm should select option (a) as it has the lower yearly interest rate.

If a policy or project has a compounding period that is not annual but has an annualised interest rate, the effective annual interest rate would need to be converted rate to match the appropriate timeline (for example, daily, monthly or quarterly etc.). For example, you may take out a loan over 10 years with an annual interest rate, however the repayments may be monthly. In this case you can rearrange the formula for the effective annual rate and solve for ( $i$ ) which is the monthly interest rate i.e., we would use the formula  $i = (1 + EAR)^{1/n} - 1$  where  $i$  is the interest rate, EAR is the effective annual interest rate,  $n$  is the number of periods for compounding. This is used more often in financial appraisals compared to social cost-benefit analysis. Once we have the appropriate interest rate that matches the compounding periods, we can use it to determine the correct loan cost to an investor.



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## Compound Interest – For Loans

In some instances, a private firm may wish to calculate the total amount that will be paid on a loan. To do this we can apply the following formula:

$$(4) \quad A = P \left(1 + \frac{i}{n}\right)^{nt}$$

where

$A$  = the amount of the loan paid

$P$  = principal of the loan



$t$  = the duration of the loan

$i$  = interest rate

$n$  = number of times interest applied per time period

This is not often used for cost-benefit analysis specifically, but the compounding formula is useful in some instances of evaluating projects from a financial approach.

## One Final Note.

This chapter considered the market and investor perspectives for cost-benefit analysis. The market perspective used market prices to evaluate a project with the consideration of fixed investment costs, salvage/horizon values and working capital. The investor or private perspective build on the market analysis as private firms pay market prices to implement a project or program. In the investor perspective, we calculated profits considering debt financing, depreciation, and taxable income. The remainder of the net benefits after this is completed is the net benefit to the private investor.

To round of this chapter, we briefly discuss how a market and private analysis would capture interest from investment and *direct* government subsidies as benefit inflows, where appropriate. These are more complicated to implement, but the basic processes are the same as demonstrated above. Interest from investments would be positive and would therefore need to have taxes paid on interest income. Direct subsidies can be treated as an additional benefit in the private analysis. A firm would not pay taxes on subsidy income (as this would be counterintuitive to the subsidy). Indirect subsidies will be covered later in the analysis.

In later chapters we will cover the social cost-benefit analysis perspective, and the distributional impacts of the social CBA. The goal of this book is to implement social CBA that evaluates potential policies, projects, and programs from the social perspective. This chapter covered important concepts that allow an analyst to identify the incentives of the investor via a market price approach. However, we still need to deal with market failures. Before we can do this, we need to revisit some important microeconomic concepts in Chapter 6, 7 and 8.

## Revision



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## Summary of Learning Objectives

1. A market CBA perspective uses cash inflows and outflows at market prices. We need to capture any salvage values and working capital changes in the market perspective.
2. The incremental analysis allows for a comparison between a base case project that is required and additional combinations of that project (relative to the base case).
3. Sunk costs are excluded from CBA. Only changes in working capital are accounted for in CBA.
4. Debt financing and depreciation are only considered in the investor perspective as the investor perspective is equivalent to a financial appraisal of a project.
5. We can evaluate a project or program from the investor perspective. The debt-to-equity ratio impacts the IRR to the private investor.





# PART 2: MICROECONOMIC FOUNDATIONS

This part provides a refresher on microeconomic foundations that are required for use in CBA. This part covers:

- (1) Demand, Supply and Market Equilibrium
- (2) Social Surpluses
- (3) The Role of Government Surplus from Interventions



# CHAPTER 6: THE THREE P'S & SOCIAL WELFARE

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## Learning Objectives

**After completing this chapter, students should be able to:**

1. Revisit the concept of allocative efficiency.
2. Describe the difference between Pareto efficiency and the Kaldor-Hicks principle.
3. Review demand and supply basics.
4. Estimate and evaluate benefits using willingness-to-pay in efficient markets.
5. Estimate and evaluate costs using opportunity cost in efficient markets.

## Microeconomics Foundations and CBA

In this chapter we will revisit some core concepts already discussed in the earlier chapters of the book including allocative efficiency and Pareto efficiency. To ensure we are effectively capturing the benefits and costs in the evaluation of an intervention we must effectively be able to measure the impacts on markets. This chapter covers impacts in non-distorted markets, highlighting how input or output markets can be used to evaluate the benefit and costs of a policy or project directly.



## Revisiting Efficiency and Cost-Benefit Analysis

In this section we will revisit some of the core microeconomic concepts that provide the foundation of welfare theory discussed in [Chapter 1](#). To evaluate whether a proposed policy or project will improve the social surplus, we identified that any project with a net social benefit ( $NSB$ ) greater than zero improves the total social benefit (i.e., social benefits exceed social costs). Specifically, although there can be winners and losers involved in policy or project, as long as the net benefit is greater than zero, the project should be undertaken as it improves total social welfare. This is because a positive net social benefit indicates the capacity to make an unambiguous improvement in welfare by compensating losers so that no-one is worse off after implementation of the project. For mutually exclusive projects, the project with the largest net social benefit should be undertaken as it provides the largest gain to society. The goal of this approach was to identify the *potential for Pareto improvement*.

In a perfectly competitive market, allocative efficiency happens automatically. Assuming the absence of market failure any project with a net social benefit greater than zero achieves allocative efficiency. If a market is efficient and no market failure exists, then an intervention by government is not necessary as it would reduce the social surplus.

When evaluating a policy or project from a social perspective, we are expecting the analysis to capture or correct market failures. Consequently, in this chapter we intend on identifying whether we should include an impact in our social CBA based on the effects observed on the market and how to use changes in social surplus to monetise impacts. If the social surplus increases under a policy or project, it is considered an increase the welfare of society and therefore the policy should be undertaken.

### Kaldor-Hicks Criterion

Cost-benefit analysis from a public sector application aims to ensure the best allocation of public resources. The public sector also aims to evaluate whether the changes in social surplus improve the welfare of society. Accordingly, one concept fundamental to cost-benefit analysis is the Kaldor-Hicks Criterion. Indirectly we have identified the Kaldor-Hicks compensation criterion in previous chapters where we discussed compensation between winners and losers. Remember that a Pareto improvement is a situation where at least one person is made better off without making anyone else worse off. The Kaldor-Hicks compensation criterion occurs when those who are made better off by a policy or project could *in theory* compensate those who are made worse off to produce a Pareto improvement. In cost-benefit analysis, if the net social benefit is greater than zero ( $NSB > 0$ ) there is an ability to compensate the losers by redistributing the benefit gains from the winners. The emphasis of the Kaldor-Hicks criterion is on the *in theory* component of the concept. Actual compensation does not actually have to occur to meet the compensation criterion – the requirement is that the winners from a policy should be able to *potentially* compensate the losers for their loss of welfare, and still be better off. This compensation criterion is the basis of welfare economics, as a policy with a positive net social benefit increases the welfare of society.

### Key Concept – Kaldor-Hicks Compensation Criterion

Kaldor-Hicks compensation criterion states that a policy is more efficient as long as there is a net gain to society as this enables compensation between winners and losers of a project, resulting in a net gain to society. Therefore, a change is “socially desirable” if it means at least one person is made better off, and the gains to that person made better off are sufficient to compensate the loser (shown through a positive change in the social surplus). When compensation occurs, it leads to an *actual* Pareto improvement.



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## Example 6.1

### Example: Kaldor-Hicks Compensation Principle

Suppose the State Government is considering building a high-speed railway into outback Queensland. Table 6.1 below lists the benefits and the costs of the project to those who have standing in the project.

**Table 6.1: Example of the Kaldor-Hicks Compensation Principle**

Stakeholder	Benefits	Costs
<b>Train Company</b>	\$100 million	
<b>Local Residents:</b>		
– Environmental degradation		\$20 million
– Noise		\$15 million

In this instance the net social benefit is greater than zero (= \$65 million). To build the railway

tracks under this project would not be Pareto efficient. Although there is a net gain of \$65 million, the local residents are made worse off by the project.

However, as  $NSB > 0$  this project meets the requirement for the Kaldor-Hicks criterion. There is an ability to compensate the local residents (losers) by taking some of the gains from the train company (winners) and re-distributing the income to the local residents.

The Kaldor-Hicks compensation criteria implies that there is potential for compensation. The compensation process may not actually happen when left to private agents in a market. However, from a public sector perspective there are instruments available to implement compensation. Specifically, the taxation system and welfare systems can be useful to policymakers for the redistribution of gains or losses from a policy. It is realistic for a CBA analyst to consider methods for compensation when evaluating a policy or project from a public sector perspective.

### Case Study: The Short-lived Carbon Tax in Australia

In July 2012, the Australian Federal Government introduced a carbon pricing scheme under the *Clean Energy Act 2011*. This “carbon tax” was expected to increase prices across a range of goods and services. Conceptually, the increase in prices caused by the carbon pricing scheme was aimed at shifting consumer preferences away from heavily carbon polluting goods and services and push consumers towards those that were considered “cleaner” or used renewable energy processes.



“Cooling towers of Dukovany Nuclear Power Plant in Dukovany, Třebíč District” by [frettie](#) licensed under [CC-BY 3.0](#)

However, this form of tax often has significant negative impacts on those at the low end of the income distribution. In this instance, low-income households were likely to spend a larger proportion of their income on the carbon tax than those on higher incomes – negatively impacting their overall welfare. The government of the time decided to use the compensation principle to redistribute income. Specifically, changes to income taxes were implemented through increasing the tax-free threshold, increases to pensioner and welfare payments. Discussion was also extended to credits towards electricity bills for aged pensioners.

This highlights the potential for policymakers to implement compensation under the Kaldor-Hicks criteria through systems already available. However, compensation is often unlikely to happen in practice.

## Limitations of the Kaldor-Hicks Compensation Criteria

It is important to note that we utilise the Kaldor-Hicks compensation criteria in cost-benefit analysis through identification of increases in social surpluses. But there are a few limitations analysts should be aware of:

(1) Compensation does not actually always occur: This raises ethical and social concerns about those groups potentially affected by a policy or project. In the carbon pricing case study above, if the Federal Government did not actively intervene and compensate low-income households, those households would have paid a larger proportion of their income to the tax and their overall personal welfare could have been negatively impacted.

(2) The compensation principle does not consider the relative wealth position: Behavioural economics highlights the concept of prospect theory. Prospect theory suggests that individuals tend to experience a stronger negative impact when faced with losses in income as compared to the positive effect associated with equivalent gains in income. In other words, the pain of losing a certain amount of money is greater than the pleasure derived from gaining the same amount of money, which can be explained by the notion of loss aversion. This applies to the losses and gains involved in cost-benefit analysis. Each individual has a different reference point that determines the values they attach to their wins and losses (see Figure 6.2 for an illustration)

(3) It must be possible to appropriately estimate the WTP/WTAs of those affected by the policy: Again, this assumes homogeneous groups of individuals. It is often assumed that the losses are the same for all those who are negatively impacted. This is a firm assumption that makes compensation in applied cost-benefit analysis difficult.

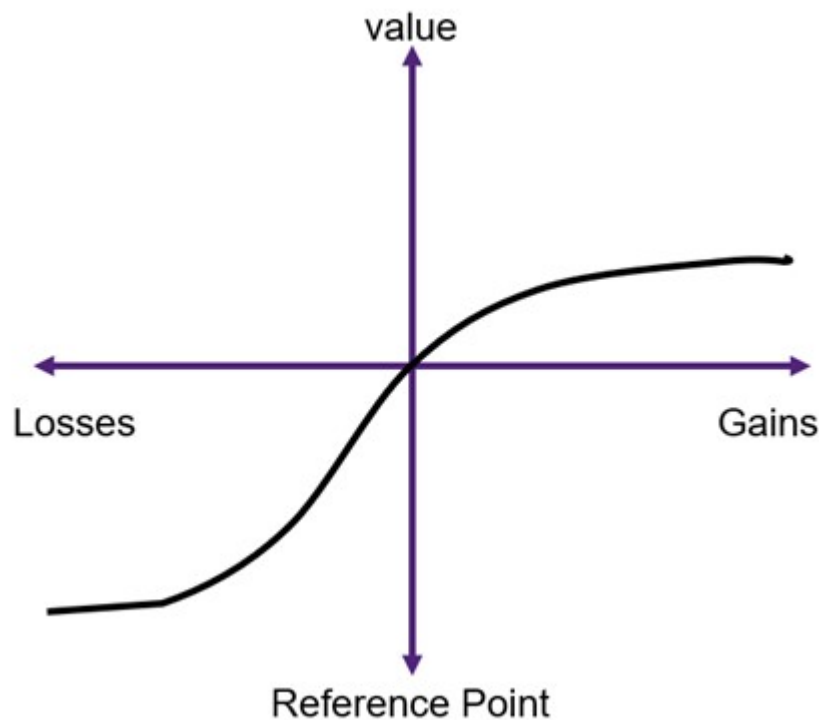


Figure 6.2:  
Prospect Theory –  
Asymmetric Value  
of Gains and  
Losses



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## Direct Market Impacts

For the purpose of this book, we will focus on the impacts in direct markets – those markets that are *directly* impacted by a project, program, or policy intervention.<sup>1</sup> For CBA in general, benefits and costs are usually measured from those sources where the impacts can be effectively observed – specifically on markets where transactions are evident. There are two types of markets we deal with – input and output markets. Benefits are measured from output markets and costs are measured from input markets. The relationship between input and output markets is illustrated in Figure 6.3.

1. Indirect or secondary markets are those which are indirectly affected by a project. In most instances secondary market impacts are sufficiently small that there is no need to account for them in a CBA.

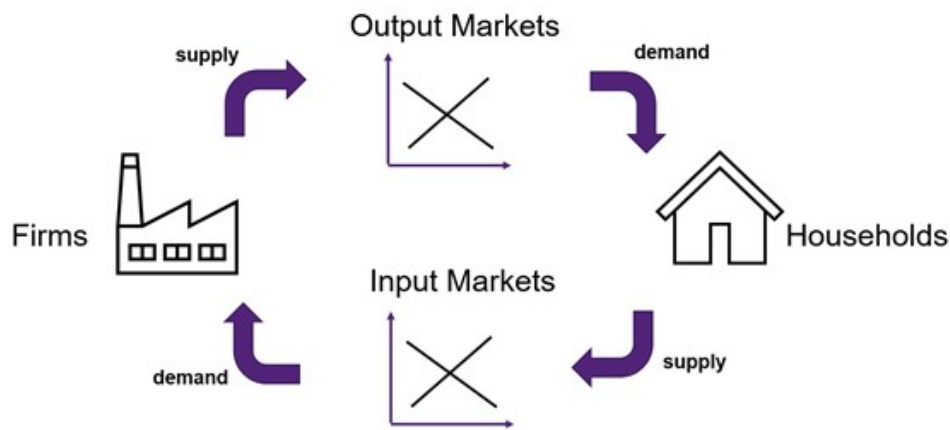


Figure 6.3: Circular Flow with Input and Output Markets

To evaluate the impacts on input and output markets from a CBA project, it is best to refresh our understanding of the concepts of willingness-to-pay and opportunity cost. For example, if a farmer was considering a sustainable tree plantation, the direct output market under consideration is the market for timber or wood as the farmer can sell the wood in the market (a benefit through income). A direct input market would be the water market, as the farmer would need to purchase water for the trees (a cost of production).



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## Willingness-to-Pay – Measuring Benefits

Benefits flow through output markets. An output market is a market where goods and services are exchanged for consumption. For example, if a farmer is considering building a new honey farm, the resulting honey from the farm would be sold on the honey market for consumption by households.

In cost-benefit analysis, benefits are measured by the **willingness-to-pay** (WTP) in the output market. WTP is easily identified by the demand curve in a market (see Figure 6.5). A consumer's willingness-to-pay is also the same as their marginal benefit (MB) from consumption of a good or service. The demand curve is downward sloping following the law of



Figure 6.4: “Christmas Tree Farm” by liljulier is marked with CC BY-SA 2.0.

demand – as price increase, the quantity demanded will decrease. To keep things simple in this analysis, we assume that demand curves are linear and can be expressed as:

- demand function  $\rightarrow Q = a - bP$
- inverse demand function  $\rightarrow P = c - \frac{1}{b} \cdot Q$

It is crucial to be able to rearrange the format of the demand curve between the direct and inverse demand functions as the inverse demand function is used for plotting on a graph as  $P$  (price) is on the y-axis. To highlight this relationship, it is important to note that  $b$  is the slope of the direct demand function and  $1/b$  is the slope of the inverse demand function.

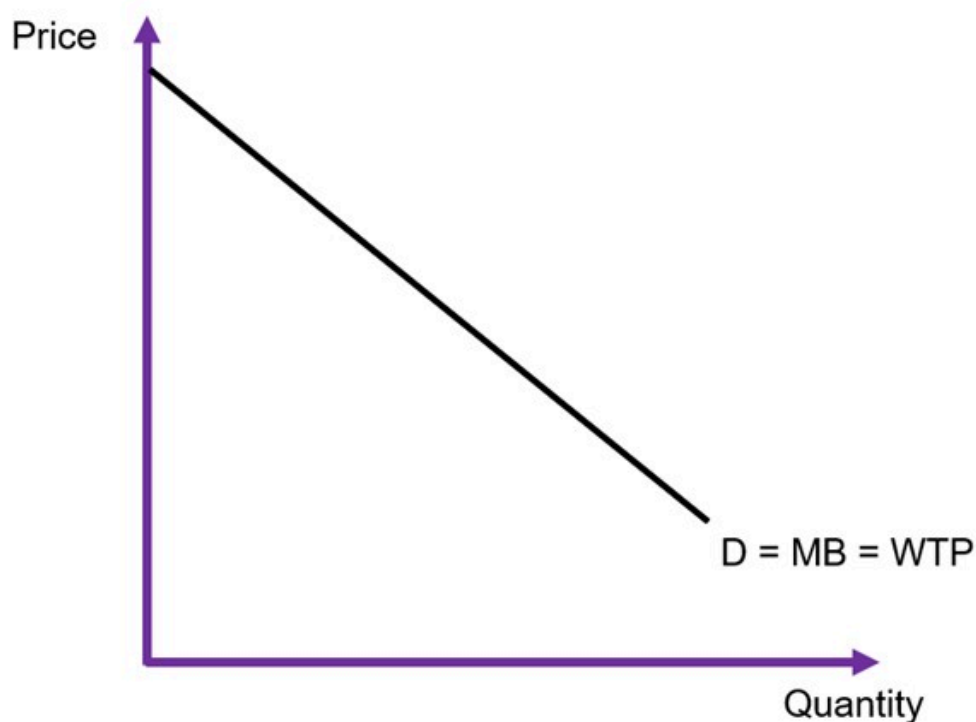


Figure 6.5: A Linear Demand Curve



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To evaluate any changes in benefits, we must calculate the changes to consumer surplus. Consumer

surplus is the gain to consumers from consuming the good or service. The total shaded area of the triangle and the rectangle in Figure 6.6 represents the total willingness-to-pay.

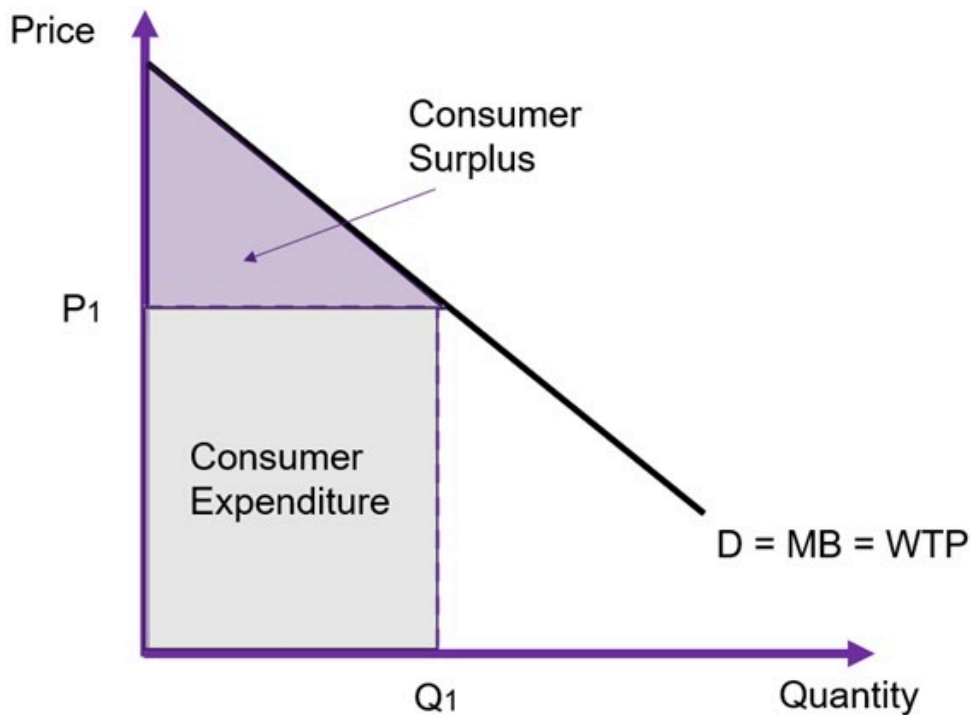
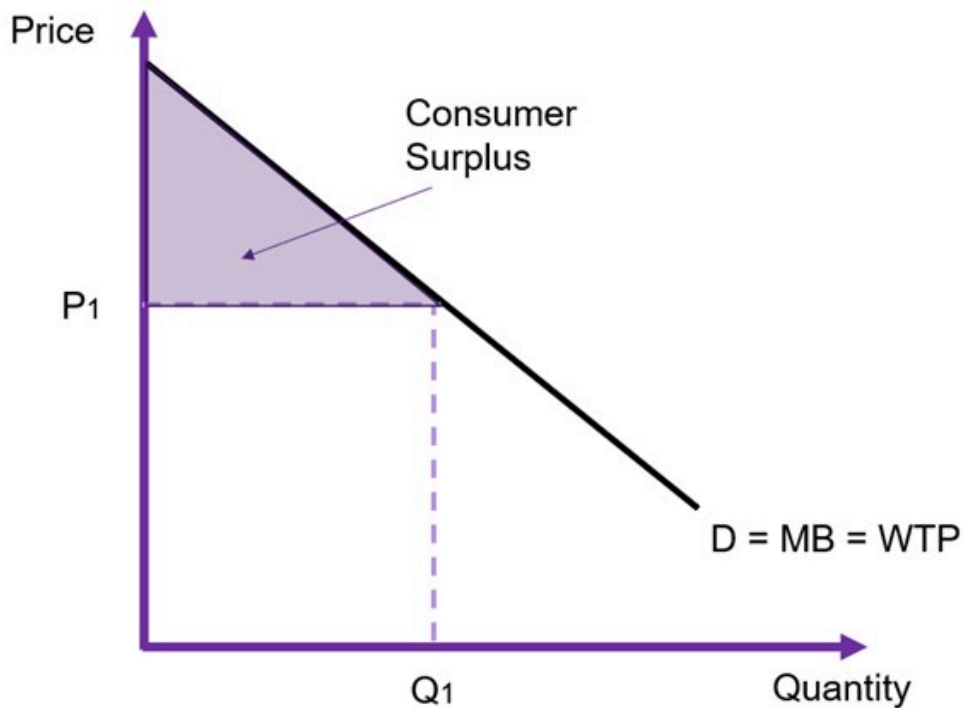


Figure 6.6: Total Expenditure at Quantity  $Q_1$  and Price  $P_1$

However, it is easier to remember that the consumer surplus is the area between the price paid by consumers and the demand curve (the WTP). This between the price and the curve as illustrated in Figure 6.7. We can calculate the consumer surplus by calculating the area of the triangle between the price  $P_1$  and the demand curve.



Figure 6.7:  
Consumer Surplus

## Example 6.2

### Example: Calculating Consumer Surplus

Assuming the intercept is \$20, the price paid by consumers is \$10 and the total quantity traded on the market is 150 units as illustrated in Figure 6.8 the consumer surplus can be calculated as

$$\begin{aligned} CS &= \frac{1}{2} \times [length \times height] \\ &= \frac{1}{2}(150 \times 10) \\ &= 750 \end{aligned}$$

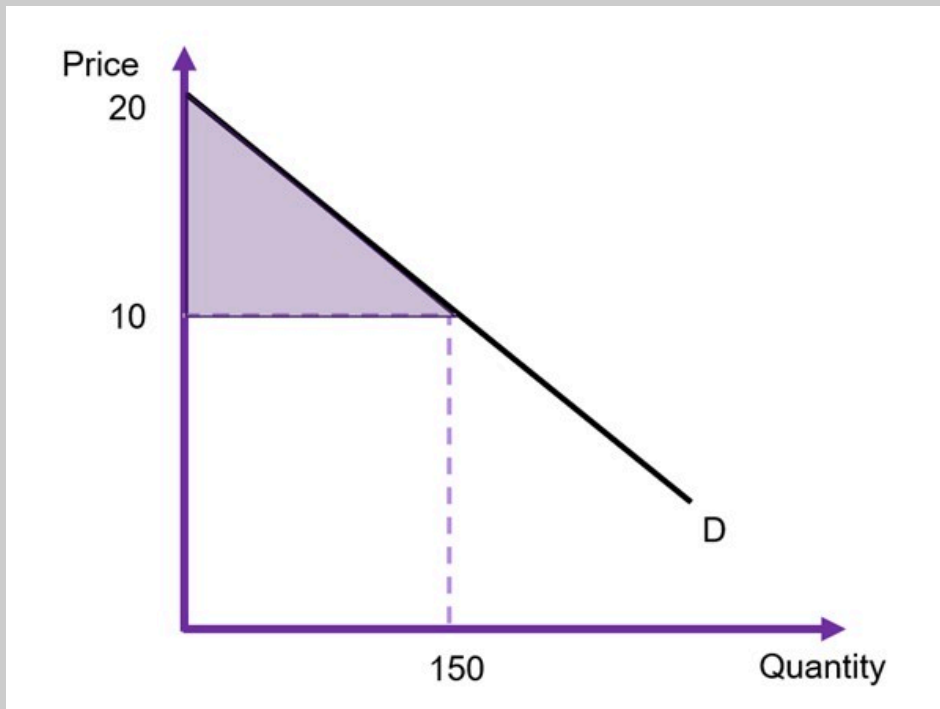


Figure 6.8:  
Example of How  
to Calculate  
Consumer Surplus

In CBA, we are interested in the change in consumer surplus from the implementation of the policy or project. Consequently, we can consider what happens when we increase or decrease the price. In Figure 6.9, we decrease the price from  $P_1$  to  $P_2$ . This increases the quantity demanded. Consequently, we can identify the shaded areas (the purple rectangle and grey triangle) as the change in consumer surplus caused by the change in the price.

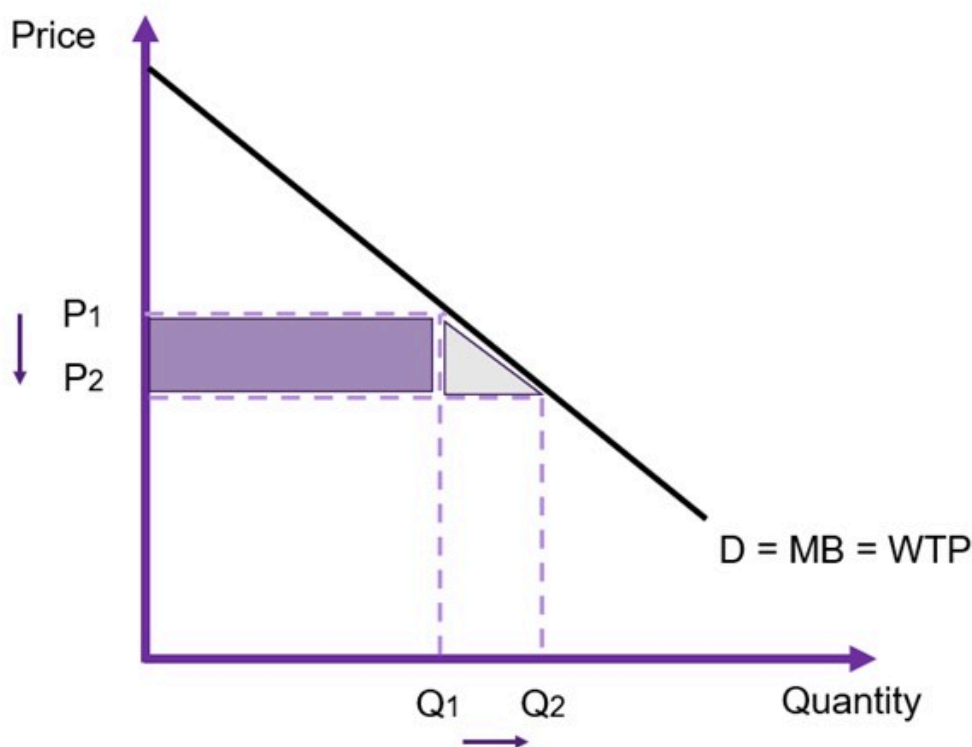


Figure 6.9: The Change in Consumer Surplus due to a Fall in Price ( $P_1$  to  $P_2$ )



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## Opportunity Costs – Measuring Costs

When estimating the cost of a policy or project we use the input markets. Input markets are resource markets. When measuring costs of a policy or project, we look at the economic well-being of producers which requires the assessment of the opportunity cost of production. The **opportunity cost** is the value of the next best alternative that we give up in order to allocate the relevant resources towards the policy or project.

More specifically, if we want to measure the full costs of a policy, we need a full accounting of opportunity costs, what we must give up if we allocate resources towards the policy. The supply curve is the representation of opportunity cost of the project. A supply curve represents the marginal cost (MC) of supplying a good. The supply curve is upward sloping due to the law of supply – as price increases, producers are willing to provide more of a good or service in the market.

Again, to keep things simple in this analysis, we assume that the supply curves are linear as illustrated in Figure 6.10. It can take two forms:

- supply function  $\rightarrow Q = a + bP$
- inverse supply function  $\rightarrow P = c + \frac{1}{b} \cdot Q$

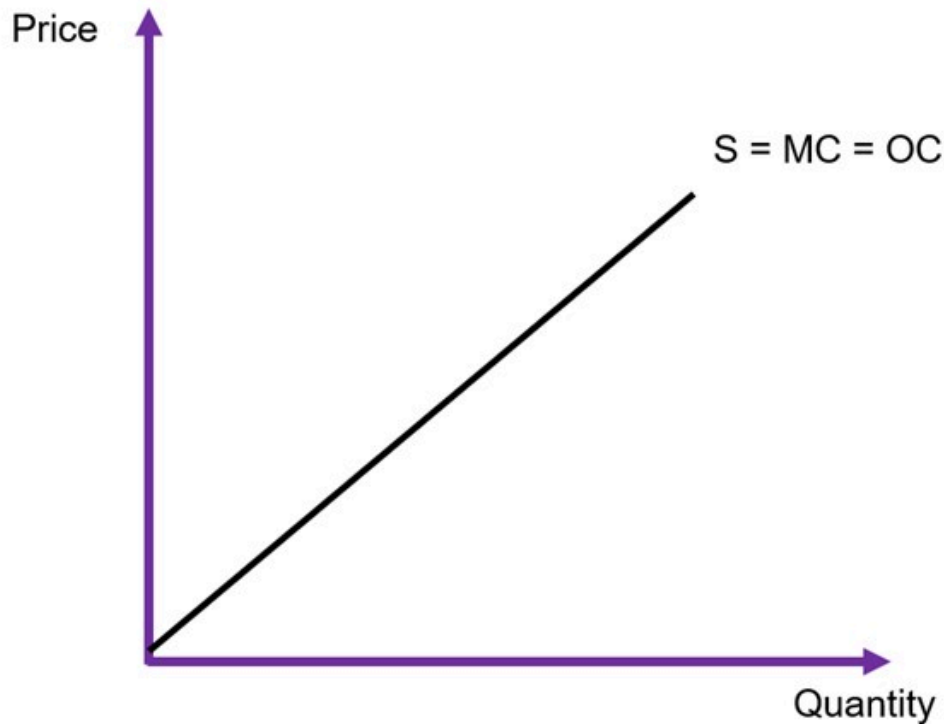


Figure 6.10: A Linear Supply Curve

The distance between the supply curve and the x-axis shows the marginal cost of production. If we want to find the total opportunity cost of production, we need to sum all the marginal costs. Using Figure 6.11 as an example, assuming the producer is supplying  $Q_1$  to the market the opportunity cost is the area under the supply curve up to the quantity supplied ( $Q_1$ ), shown by the grey area. The area of  $P_1 \times Q_1$  is the total price received by the suppliers. Therefore, the difference between the total received and the total cost of production (the grey area) is the economic rent – or more specifically, the producer surplus.

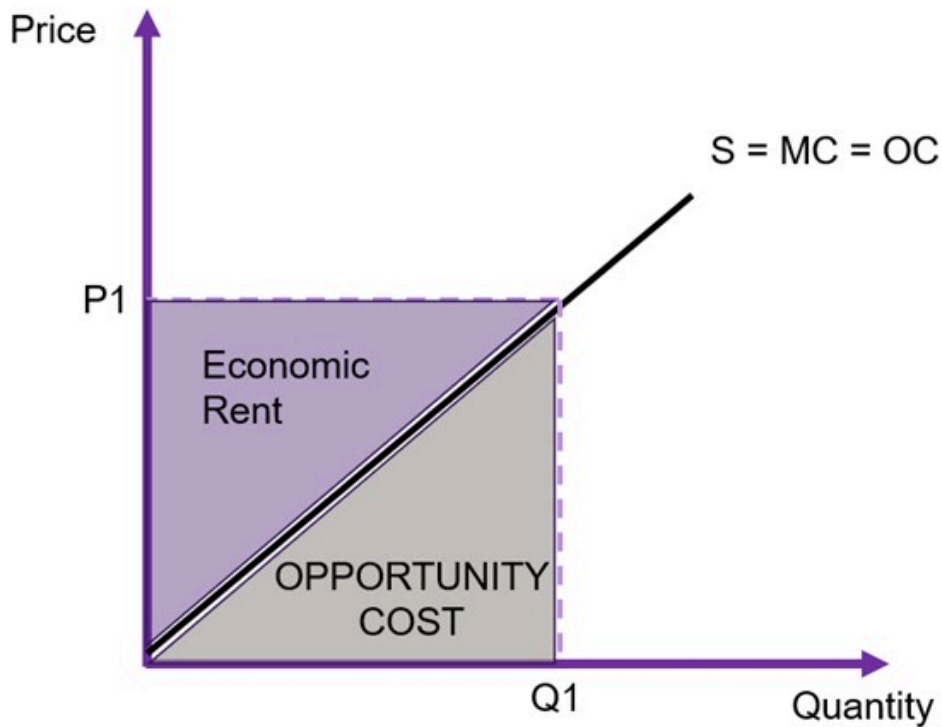


Figure 6.11:  
Opportunity Cost  
and Economic  
Rent

To evaluate any changes in costs, we must calculate the changes to producer surplus. Producer surplus is the gain to suppliers of a good or service in the form of economic rent. The total shaded area of the triangle and the rectangle in Figure 6.12 represents the total producer surplus. Again, we calculate the area of a triangle, assuming a linear supply curve. When looking at changes in producer surplus the approach is the same as identified in Example 6.2 above for changes in consumer surplus.

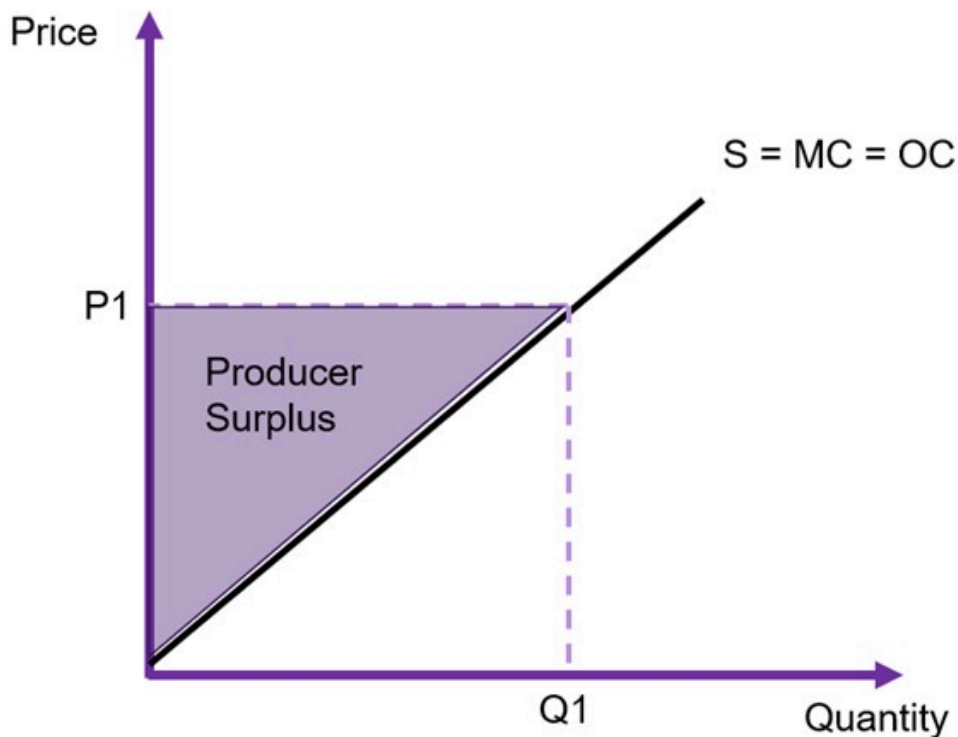


Figure 6.12:  
Producer Surplus

It is important to note that if the supply curve is vertical, there is only producer surplus (economic rent). If the supply curve is horizontal, there is only opportunity cost and there is no producer surplus.



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<https://uq.pressbooks.pub/socialcba/?p=429#h5p-118>

## Market Equilibrium and Social Surplus

Assuming the only participants in the market are producers and consumers, the social surplus can be identified as:

$$(1) \text{ Social Surplus (SS)} = \text{Consumer Surplus (CS)} + \text{Producer Surplus (PS)}$$

The market is in equilibrium when demand is equal to supply. If the market is in equilibrium (as shown in Figure 6.13 below), the equilibrium price is  $P^*$  and the equilibrium quantity is  $Q^*$ , found by equating the demand and supply curves and solving algebraically.

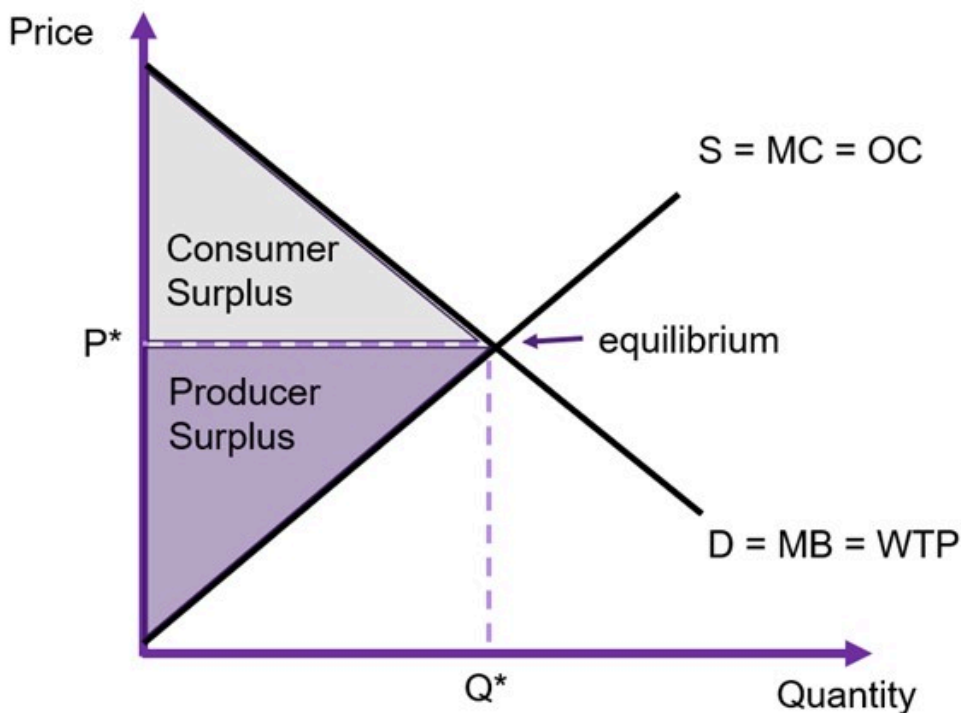


Figure 6.13: An Efficient Market Where Social Surplus is Maximised

At market equilibrium, the social surplus is at its maximum, and the market is allocatively efficient. Assuming the absence of market failures, the marginal benefit (MB) will also be equal to the marginal cost (MC), implying that the perfectly competitive market is efficient.

We also consider a perfectly competitive market *Kaldor-Hicks efficient*. Kaldor-Hicks efficiency is where there is no alternative that improves the distribution of benefits as a whole i.e., no potential Kaldor-Hicks improvement through compensation from this situation exists.

### Key Concept – Kaldor-Hicks Efficient

A situation where there is no potential for a Kaldor-Hicks improvement via the compensation principle.

When evaluating a policy in a cost-benefit analysis framework, an analyst can use the total change in social surplus ( $\Delta SS$ ) in all relevant input and output markets to measure the impacts of the intervention. Consequently, we need to sum the changes in surpluses across all markets to determine whether a policy or project is overall viable.

$$(2) \quad \Delta SS = \Delta SS_{output} + \Delta SS_{input}$$

## Elasticity

The demand curve is often unknown to an analyst, creating difficulties estimating the consumer surplus. However, we can identify the elasticity – which measures responsiveness of one variable to changes in another variable.

### Key Concept – Elasticity

Elasticity measures the responsiveness of the quantity demanded (or supplied) in response to a change in price.

The point elasticity of demand and supply can be found using the following equations:

$$(3) \quad \text{Point Elasticity of Demand}(e_d) = \frac{\Delta Q_d}{\Delta P} \times \frac{P}{Q_d}$$

$$(4) \quad \text{Point Elasticity of Supply}(e_s) = \frac{\Delta Q_s}{\Delta P} \times \frac{P}{Q_s}$$

To calculate the elasticities, you need one single point on the relevant curve where you observe both a

price and a quantity. The change in quantity over the change in price is the slope of the *direct* demand/supply curve i.e., use the  $Q = f(P)$  format to find the first term in equations (3) and (4).

- When the elasticity is equal to zero (0) it is *perfectly inelastic*
- When the elasticity is between  $|1| < e < 0$  it is *relatively inelastic*
- When the elasticity is equal to the absolute value of one ( i.e.  $|1| = 1$  ) it is *unit (or unitary) elastic*
- When the elasticity is between  $\infty < e < |1|$  it is *relatively elastic*
- When the elasticity is equal to  $\infty$  it is *perfectly elastic*

The elasticity of demand usually results in a negative value. This is due to the law of demand – there is an inverse relationship between price and quantity demanded. As highlighted above, when we refer to the elasticity of demand, we usually use the *absolute value* as the negative relationship is implied (indicated by two vertical bars  $| |$  around the number). Hence, we talk about the absolute value of the elasticity.

Figure 6.14 below shows a comparison of a relatively elastic demand curve and a relatively inelastic demand curve.

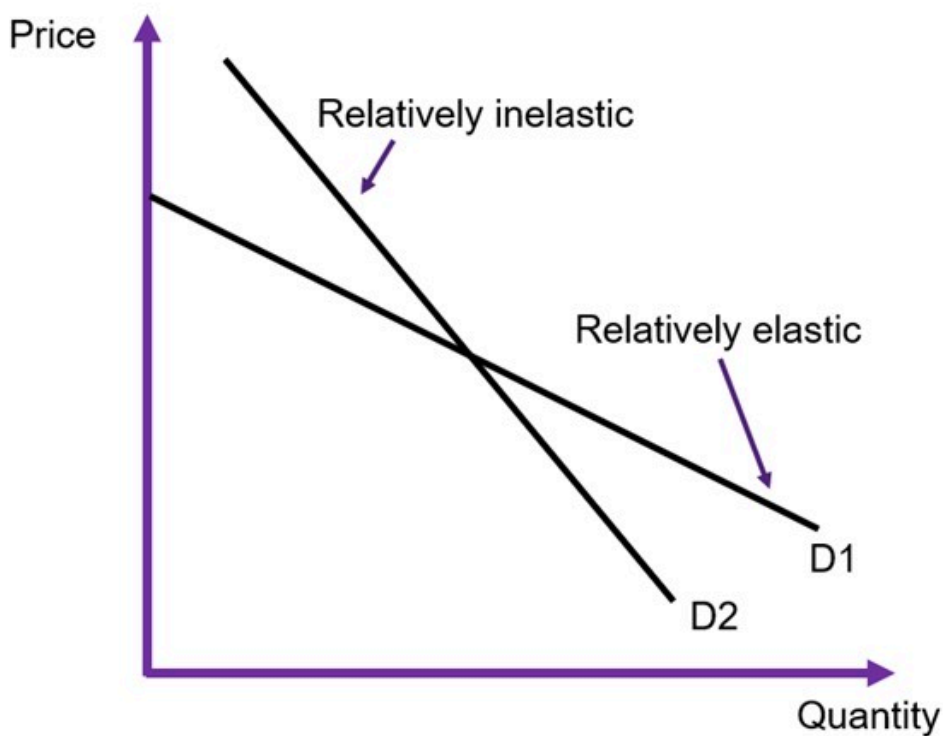


Figure 6.14:  
Relative  
Elasticities

Remember that the slope of the curve and the elasticity is not the same thing! The slope is only one component of the elasticity formula. It is important to note that the elasticity changes as we move along the curve as illustrated in Figure 6.15.

Understanding elasticity is important to evaluate the behavioural response of economic agents to an intervention in the market. However, understanding the elasticity of demand is most important in cost-benefit analysis as it allows us to determine what is likely to happen to the consumer surplus:



- If a good or service is relatively elastic, then when the price changes there is a large change in the quantity demanded. Consequently, there will be a large change in consumer surplus.
- If a good or service is relatively inelastic, then when the price changes there is a small/ potentially no change in the quantity demanded. Consequently, there will be a small to no change in consumer surplus.

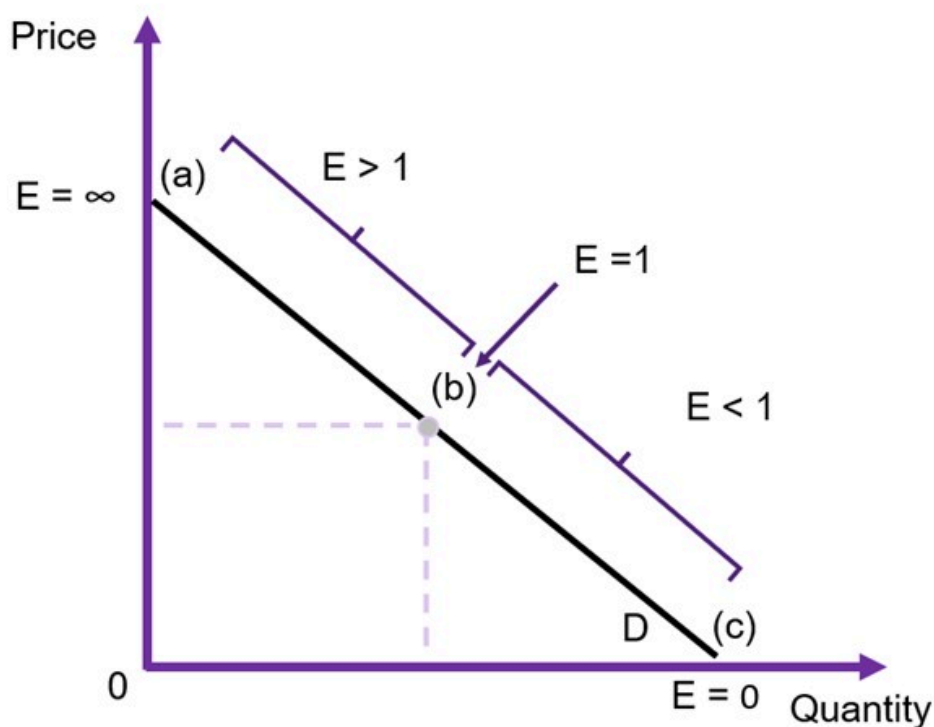


Figure 6.15: Point Elasticities Along the Demand Curve

### Example 6.3

#### Example: Point Elasticity Along the Demand Curve

Suppose you have the information supplied in Figure 6.16 below and you would like to calculate the elasticity of demand at points (a), (b), and (c).

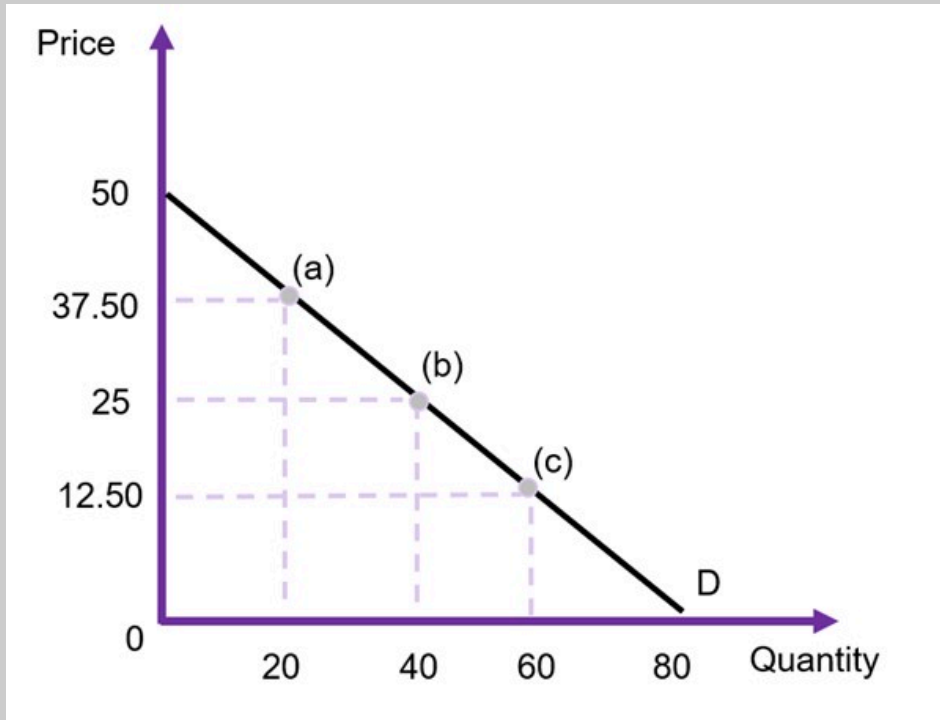


Figure 6.16:  
Calculating Point  
Elasticity of  
Demand.

To calculate the elasticity, we first need to find the demand curve with quantity demanded as a function of price i.e., in the format of  $Q = a - bP$ . Taking the information from the figure, the curve is:

$$Q = 80 - 1.6P$$

The intercept of 80 is identified where price is equal to zero (on the x-axis), and the -1.6 comes from the slope of the curve. Specifically, as we are identifying the direct demand curve it would be the *inverse* of the indirect demand curve slope (50/80) which is observed in the graph. i.e., the slope  $b = -(80/50) = -1.6$

Using the information on quantity and prices  $Q = 20$  and  $P = 37.50$  at point (a) and applying equation 3, we get the following:

$$\begin{aligned} PED_a &= -1.6 \times \frac{37.50}{20} \\ &= -3 \end{aligned}$$

At point (b),  $Q = 40$  and  $P = 25$ , therefore  $PED_b = -1.6 \times 25/40 = -1$

At point (c),  $Q = 60$  and  $P = 12.50$ , therefore  $PED_c = -1.6 \times 12.50/60 = -1/3$

This example shows that point (a) is relatively elastic, point (b) is unit elastic and point (c) is inelastic.

## A Challenger Appears – Government Surplus

To identify changes in social surplus to a cost-benefit analysis framework, one of the most important things we need to also consider is the change in **government surplus**. Specifically, from a public sector approach to cost-benefit analysis, we must consider the impact of the government on the market when undertaking a policy.

When the government is an agent in the implementation of a policy or project, we must include changes in government surpluses in a CBA. Therefore, we can expand equation (2) to capture changes in government surplus:

$$(5) \quad \Delta Social\ Surplus\ (SS) = \Delta Consumer\ Surplus\ (CS) + \Delta Producer\ Surplus\ (PS) + \Delta Government\ Surplus\ (GS)$$

Hence, equation 5 shows that changes in consumer surplus, producer surplus, and government surplus can be used to measure the impacts of a policy, project, or program. If the social surplus increases under the policy, then the project is considered a potential Pareto improvement. Remembering that the total change in social surplus in this instance correlates with an increase in net benefits to society, when the  $\Delta SS > 0$  the project should be undertaken.

In this section we will consider some examples where governments may choose to intervene in a market, and how it affects the total social surplus. The assumption is there are no market distortions or market failures. i.e., the market is perfectly competitive (efficient), and interventions are occurring.

## Government Intervening in Output Markets

### Government Affecting Supply in an Output Market (WTP)

Governments can choose to intervene in efficient markets. If the social surplus increases under the government intervention, then the policy increases the net benefit to society. We can analyse the impact of these interventions by looking at the change in the surpluses. We consider three scenarios: (1) the government provides the good or service, (2) the government reduces the price of the good or service through production costs, and (3) the government controls the pricing of the good or service.

#### (1) The government providing the good or service to the market.

When the government decides to provide a good or service direct to the market, the government becomes a supplier along with private firms. Suppose the government is willing to provide  $q'$  units. There are two possible scenarios that depend on the elasticity of demand.

### Perfectly Elastic Demand

Assume the demand is horizontal (perfectly elastic) and the supply curve is upward sloping (as shown in Figure 6.17). Prior to intervention, the market is in equilibrium at  $P_1$  and  $Q_1$  at point (a). Once the government intervenes and provides  $q'$  units direct to the market, the supply curve shifts from  $S$  to  $S + q'$ . Given the demand curve is perfectly elastic (horizontal), the market price is not affected by government intervention – it remains at  $P_1$ . We can evaluate the impact of this policy by looking at the changes in the social surplus.

- Consumer surplus is unchanged (zero).
- Producer surplus is unchanged.
- Government surplus (via revenue) is equivalent to  $q' \times P_1$  [or the area of  $Q_1.(a).(b).Q_2$ ].

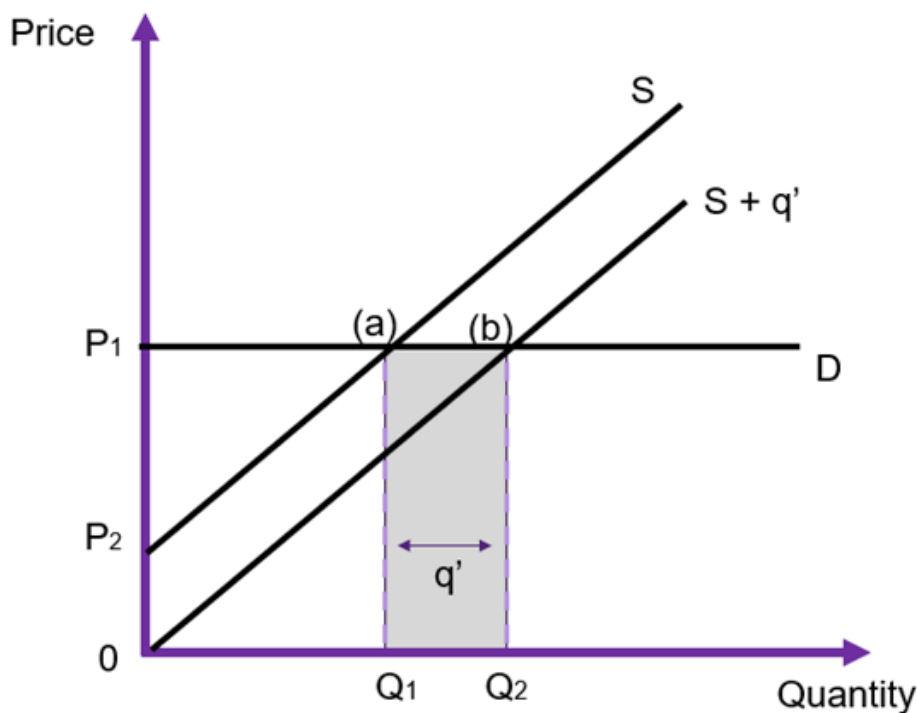


Figure 6.17:  
Government  
Supplying to the  
Output Market  
with Elastic  
Demand



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### General Case

Assuming instead that the demand is downward sloping, and the supply curve is upward sloping (as

shown in Figure 6.18). Prior to intervention, the market is in equilibrium at  $P_1$  and  $Q_1$  at point (c). When the government intervenes and provides  $q'$  units direct to the market, the supply curve shifts from  $S$  to  $S + q'$ . However, this time the price changes on the market, falling from  $P_1$  to  $P_2$ , and the new equilibrium is at point (b) as shown in Figure 6.18. We can evaluate the impact of this policy by looking at the changes in the social surplus:

- Consumer surplus is originally  $P_3.(c).P_1$ , with the drop in price the consumer surplus increases to  $P_3.(b).P_2$  – the difference between the two is the right-angled trapezoid  $P_1.(c).(b).P_2$ .
- Producer surplus was originally  $P_1.(c).P_4$ , with the drop in price the new producer surplus becomes  $P_2.(a).P_4$ . As the price on the market falls due to the increased supply, there is a crowding out effect for the producers originally in the market (private production falls from  $Q_1$  to  $Q_2$ ). In the example Figure 6.18, this net change will be positive, however whether this happens will depend on the size of  $q'$  supplied by the government and the elasticity of demand and/or supply.
- Government revenue will be equivalent to  $q' \times P_2$  [or the area of  $Q_2.(a).(b)Q_3$ ]

Overall, the reduction in producer surplus  $P_1.(c).(a).P_2$  is transferred to consumer surplus and there is a positive government surplus through revenue. The net gain in social surplus is therefore  $\Delta SS = \text{area of } (a).(b).(c) + q'.P_2$ .

In this instance, the government is able to provide a benefit that we can evaluate using the CBA framework using the willingness-to-pay. The intervention has a direct increase to the supply of the good or service along with a decrease in the price. Accordingly in this scenario, consumers are made better off after the redistribution of surpluses.

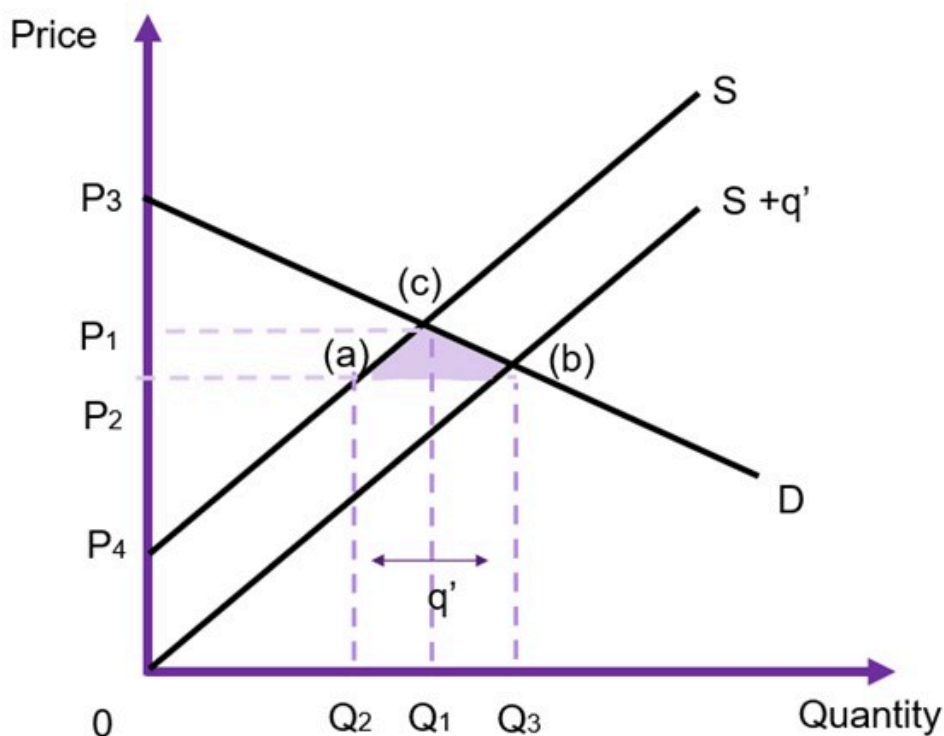


Figure 6.18:  
General Case  
Government  
Supplying to an  
Output Market  
Increasing the  
Price

### Perfectly Inelastic Supply

Let's now consider the situation where a government provides the good or service, assuming the supply is vertical (perfectly inelastic) and the demand curve is downward sloping (as shown in Figure 6.19). Prior to intervention, the market is in equilibrium at  $P_1$  and  $Q_1$  at point (a). Once the government intervenes and provides  $q'$  units direct to the market, the supply curve shifts from  $S$  to  $S + q'$ . Given the supply curve is perfectly inelastic (vertical), the market price falls directly from the government intervention. We can evaluate the impact of this policy by looking at the changes in the social surplus.

- Consumer surplus increases from  $P_3 \cdot (a) \cdot P_1$  to  $P_3 \cdot (b) \cdot P_2$ . Consumer surplus therefore increases by  $P_1 \cdot (a) \cdot (b) \cdot P_2$ .
- Producer surplus decreases from  $P_1 \cdot (a) \cdot Q_1 \cdot 0$  to  $P_2 \cdot (c) \cdot Q_1 \cdot 0$ . The rectangle  $P_1 \cdot (a) \cdot (c) \cdot P_2$  is transferred from producers to consumers.
- Government surplus (via revenue) is equivalent to  $q' \times P_2$  [or the area of  $Q_1 \cdot (c) \cdot (b) \cdot Q_2$ ].

In this example, the goal of the government intervention is to reduce the price. Applications of this situation are limited however a good example is higher education. Many countries have higher education regulations where often placements are limited to the number of facilities available or private firms seek to maintain prestige. If the government increases supply, it can be via opening new higher education facilities to reduce the price. The overall net gain to society is  $\Delta SS = \text{area of } (a) \cdot (b) \cdot (c) + q' P_2$  which is the gain to consumers minus the loss to producers plus the gain to the government via revenue.

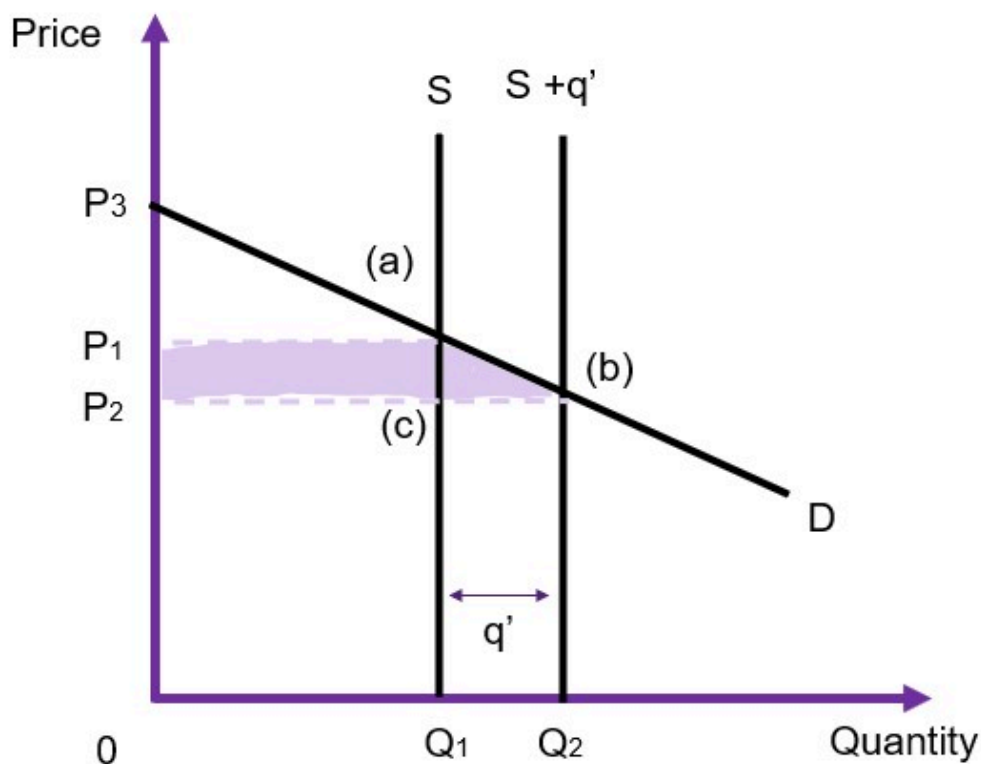


Fig 6.19:  
Government  
Supplying to an  
Output Market  
with Fixed Supply

## Government Reducing the Price (WTP)

### (2) Government Reducing the Cost of Production.

In output markets, the second alternative for government policy is to intervene and reduce the cost of production. This can be through the provision of technology that enhances production or reduction in prices in inputs for production of the output being evaluated. In these situations, it involves a policy that shifts the supply curve to the left (downwards), lowering the cost of supplying the good or service to the market. In these instances, the additional output is supplied by private firms (and not provided by the government).

#### General Case

Assume that the demand is downward sloping, and the supply curve is upward sloping (as shown in Figure 6.20). Prior to intervention, the market is in equilibrium at  $P_1$  and  $Q_1$  at point (c). When the government intervenes to alter the cost of production, private firms produce  $q^*$  additional units direct to the market, increasing the supply from  $S$  to  $S + q^*$ . This drives the market price down from  $P_1$  to  $P_2$ . We can evaluate the impact of this policy by looking at the changes in the social surplus.

- Consumer surplus increases from  $P_3.(c).P_1$  to  $P_3.(b).P_2$ . An increase of  $P_1.(c).(b).P_2$ .
- Producer surplus moves from  $P_1.(c).P_4$  to  $P_2.(b).0$ .<sup>2</sup> The producer gains  $P_4.(a).(b).0$  from the reduction in the cost of production reducing the marginal cost. However, the producer also loses  $P_1.(c).(a).P_2$  which is transferred to the consumers. As the grey shaded area is larger than the purple shaded area, the producer is better off in this example.
- Government surplus is unchanged as the government is not supplying to the market.

In this example, the total change in the social surplus is the trapezoid  $P_4.(c).(b).0$  due to part of the producer surplus gain transferring to the consumers.

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2. Note that 0 (zero) may not always be the intercept for the supply curve. It was selected for this example to keep it simplistic

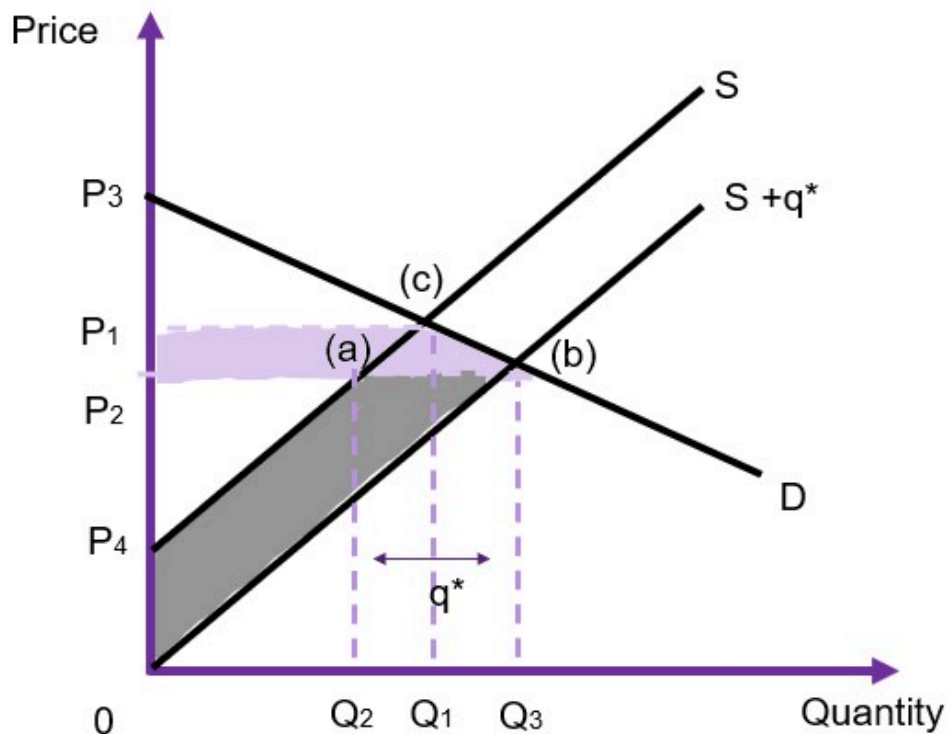


Figure 6.20:  
Government  
Intervention in an  
Output Market by  
Influencing Cost  
of Production

### (3) Government Controlling the Price of a Good

The government can control the price of goods or services in output markets. Examples include price ceilings (maximum price of bread) and price floors (minimum wages). These interventions are complex and can create market failures. We will cover these in more detail in [Chapter 8](#). However, we provide an example on how to evaluate the impacts of a price floor below in [Example 6.4](#).

#### Example 6.4

In 2018, the Northern Territory government implemented a [price floor on alcohol](#). The policy aimed to address two factors: (1) residents of NT consume 14 litres or more per year than the average Australian ([Skov, et.al., 2010](#)), and (2) the total social cost of alcohol was estimated at \$7,577.94 per adult in the NT ([Smith, Whetton, & d'Abbs, 2019](#)).

Following the implementation of the price floor, the following data was collected on the wholesale price of alcohol is reported below in [Table 6.2](#).



Table 2: Wholesale PAC Supply - Northern Territory

	2012	2013	2014	2015	2016	2017	2018	2019
Cider	101,491	114,316	121,448	117,494	116,072	108,730	100,048	94,133
Total Wine	516,836	520,761	518,614	511,874	516,761	515,436	488,759	403,396
Total Spirits	721,282	680,784	664,486	642,131	652,871	638,675	651,396	649,266
Total Beer	1,394,355	1,371,219	1,356,887	1,331,514	1,342,744	1,356,524	1,298,431	1,232,799
<b>Total</b>	<b>2,733,964</b>	<b>2,687,080</b>	<b>2,661,435</b>	<b>2,603,013</b>	<b>2,628,448</b>	<b>2,619,364</b>	<b>2,538,633</b>	<b>2,379,593</b>

Table 6.2:  
Wholesale PAC  
Supply  
(Department of  
Industry, Tourism  
& Trade, 2021)

Using this information, we can estimate the change in social surplus from this policy (illustrated in Figure 6.21 below). As the policy is a price floor, the minimum price will be \$1.30 and the quantity reduced from 2.53 million to 2.37 million.<sup>3</sup> The deadweight loss of the policy is the area D+E. Hence, we can calculate the social cost of the project – assuming D and E are equal in size, and both demand and supply are linear) of \$15,904. Remembering that this deadweight loss exists to offset improved benefits in terms of social impacts of alcohol, the government is attempting to correct the economic cost of alcohol by reducing the consumption of alcohol.

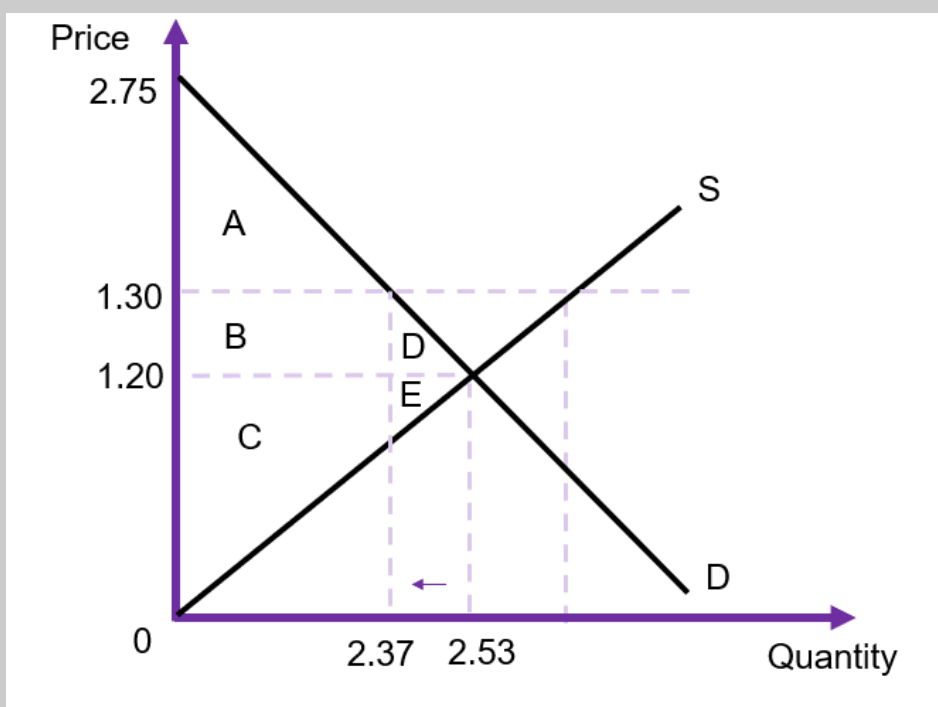


Figure 6.21: A  
Hypothetical  
Example of an  
Alcohol Price Floor  
in the Northern  
Territory

3. Assuming the intercept of the demand curve is \$2.75 and the competitive market equilibrium is \$1.20

## Government Purchasing from Input Markets (OC)

When evaluating the impacts of a policy or project, the government may purchase resources to be used in the project. For example, if a government is planning on building a new road, then the government will need to purchase concrete and steel from the input markets. This means that the government enters the market as a consumer and will affect the *demand* for the input. To measure the costs associated with inputs, we use opportunity costs. The opportunity cost of a resource used in a policy or project is equal to the change in the social surplus in the input market. Usually, we can evaluate this opportunity cost via the budgetary outlay i.e., the amount spent by the government to purchase the good or service in the input market.

Keeping in mind that resource markets often have horizontal or vertical supply curves. These situations occur if the government is a price taker in the market (such as low skilled labour) or if there is a fixed supply of the resource (such as land). In these situations, we can calculate the expenditure of the government as the opportunity cost for the project.

### Horizontal Supply

In the case where the supply curve is horizontal, there is no change in consumer or producer surpluses. The price is unaffected, remaining at  $P_1$  as the increased demand from the government shifts the demand curve from  $D$  to  $D + q'$ . The only change in this market is the  $q' \times P_1$  units which is the expenditure on the government. Consequently, in this example, the opportunity cost is reflected in the shaded rectangle in Figure 6.22.

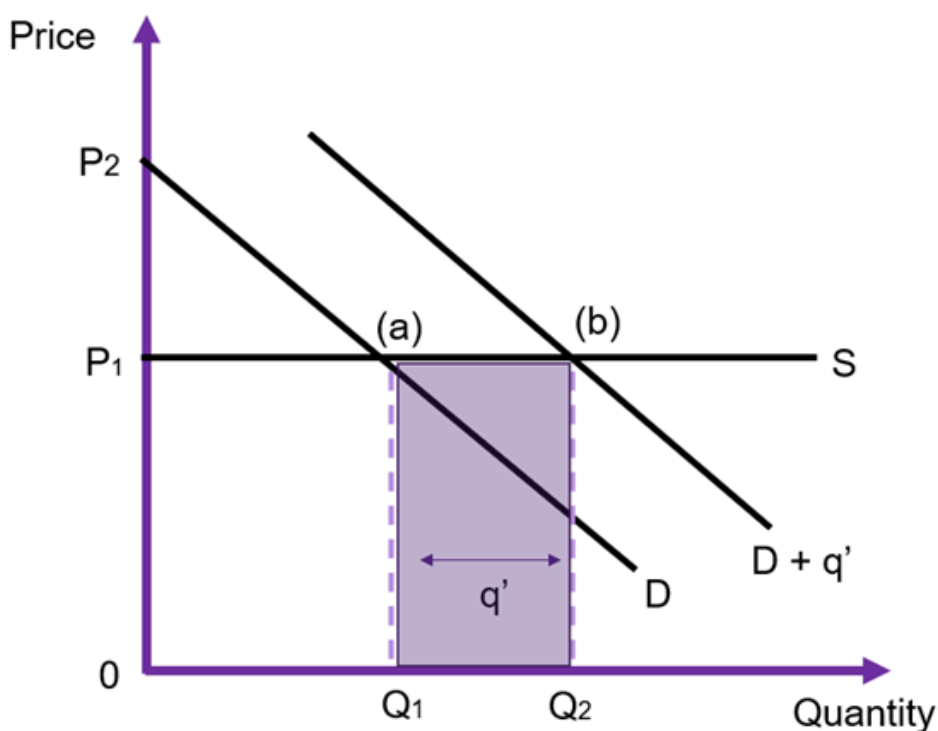


Figure 6.22:  
Government  
Purchasing from  
an Input  
(Resource) Market  
with Perfectly  
Elastic Supply

### Vertical Supply

In the case where the supply curve is vertical, there is no change in consumer surplus (assuming a parallel shift in the demand curve). The price will increase from  $P_1$  to  $P_2$  as the increased demand from the government shifts the demand curve from  $D$  to  $D + q'$ .

The only change in this market is the  $q' \times (P_2 - P_1)$  units which is the expenditure on the additional economic rent to the resource that the producer will receive. Consequently, in this example, the change in producer surplus is reflected in the shaded rectangle in Figure 6.23.

Comparing the result in Figure 6.23 with the example above in Figure 6.22, we can see that there is *no opportunity cost* from this policy intervention. Only producer surplus increased. However, this increase in price should be captured in the CBA.

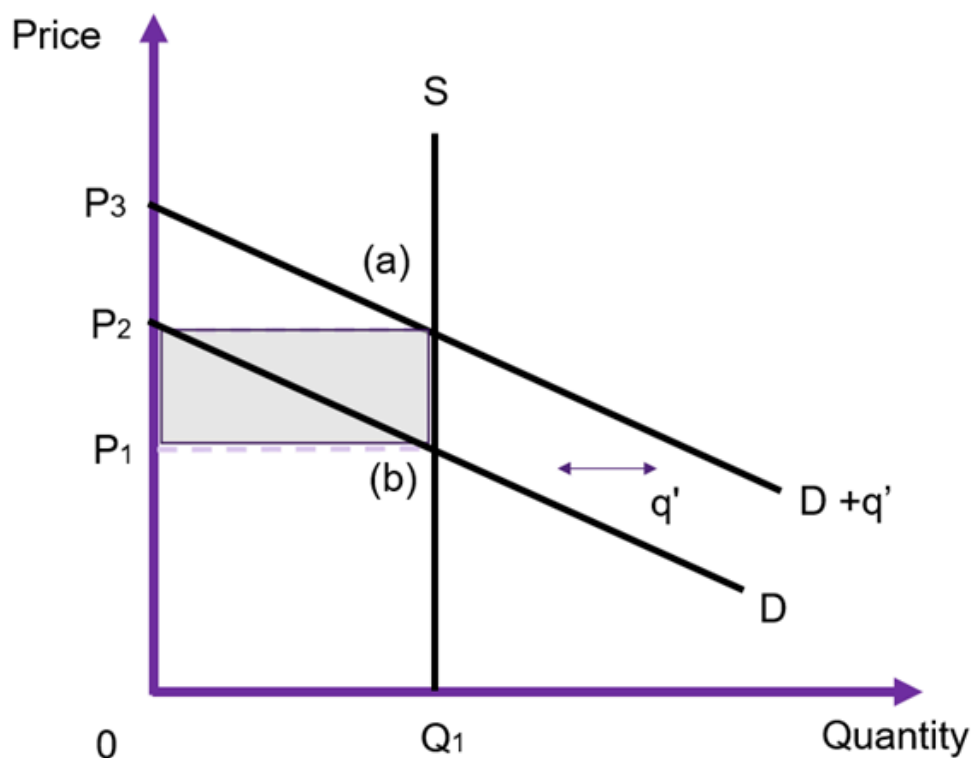


Figure 6.23:  
Government  
Purchasing from  
an Input  
(resource) Market  
with Perfectly  
Inelastic Supply

### General Case

When the input market follows the general market example – downward sloping demand and upward sloping supply, there will be a change in the market price. The size of the change in the market price depends on the relative elasticities.

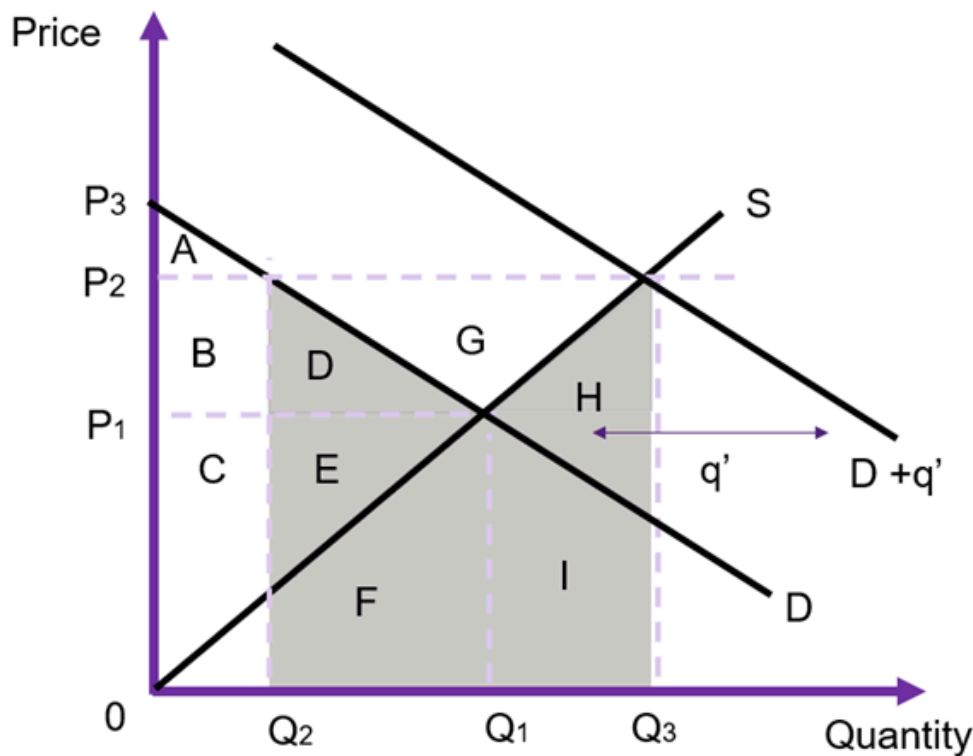


Figure 6.24: Using Budgetary Outlay as a Proxy for Opportunity Cost

If we assume the government is demanding the resource, the government intervention increases the demand by  $q'$  the price for the input will increase from  $P_1$  to  $P_2$  as shown in Figure 6.24. As the government is purchasing  $q'$  units at the higher price of  $P_2$  the total expenditure on the input by the government is equivalent to the area of  $(D+E+F+G+H+I)$ . However, the social cost is  $(D+E+F+H+I)$ . The difference between the two is  $G$ .  $D+E$  is the social opportunity cost to other consumers on the market (a loss caused by an increase in the market price). These private consumers have been *crowded out* due to the higher price i.e., before the intervention  $Q_1$  units was demanded by private firms and after the increase in the price, private consumers demand  $Q_2$  units.  $B+D+G$  is the gain to producers from providing more of the input on the market. Finally,  $F+H+I$  is the opportunity cost to the producers on the market as the government demands increases the quantity traded on the market to  $Q_3$ .

Given this information, triangle  $G$  is the difference between the opportunity cost and the budgetary outlay. This can be seen broken down in Table 6.3 below. Therefore, the price change must be accounted for in computing the opportunity cost of production.

**Table 6.3: Distribution of Benefits and Costs for General Market Example**

	Benefit	Cost
<b>Consumer Surplus</b>		$B+D$
<b>Producer Surplus</b>	$B+D+G$	
<b>Government Surplus</b>		$D+E+F+G+H+I$
<b>Net Social Cost</b>		$D+E+F+H+I$

If the cost to the government is close to the opportunity cost, we can use the government expenditure to value the impact in the input market (given by  $G$ ). If the cost is not close to the government expenditure as illustrated in Figure 6.24 (i.e., the area of  $G$  is large) then it is not appropriate to use the government expenditure to account for the cost of the intervention. The size of  $G$  will depend on the relative elasticities of demand and supply.

One way to calculate the price that should be used in the cost-benefit analysis to reflect the opportunity cost is to average the new price and the old price ( $(P_1 + P_2)/2$ ). This is essentially a proxy **shadow price** due to the market distortion caused by the government intervention. We will look at shadow prices for other market distortions and non-market goods and services as a later date.

### Key Concept – Shadow Price

A shadow price is an estimated monetary price used to value an item, good or service that is not traded on a market, or the market price does not reflect the true value.

In this instance, we are calculating the shadow price by adjusting the changes for the market price caused by the government intervention. We can take the average of the two shadow prices and multiply it by the quantity purchased by the government to calculate the opportunity cost from an intervention in the input market. i.e.,  $OC = q' \times \frac{P_1 + P_2}{2}$ .



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## Example 6.5

### Additional Example: Price Support with No Surplus

Suppose a government wants to protect its agricultural industries – for example wheat farmers. If we consider a price floor as policy intervention, with *no surplus* on the market we can evaluate the impact of the policy on social welfare. This is often referred to as a *price support*. The key difference between a price floor and a price support is that when a price floor exists, the excess supply is a problem faced by the suppliers in the market. When it is a price support, the government purchases the surplus product. We can evaluate this type of intervention using the changes in social surplus.

Prior to the price floor, the equilibrium price is  $P_1$  and the quantity traded is  $Q_1$  as shown on Figure 6.25. After implementing the price support the price becomes  $P_s$ . At price  $P_s$  the consumers demand  $Q_2$  units, and suppliers are willing to supply  $Q_3$  units to the market. The government will have to purchase the grey rectangle. The resulting total social surplus is outlined in Table 6.4. From the analysis, this intervention benefits producers, costs consumers and the government. Whether the overall policy should be accepted will depend on whether the overall change in social surplus is positive.

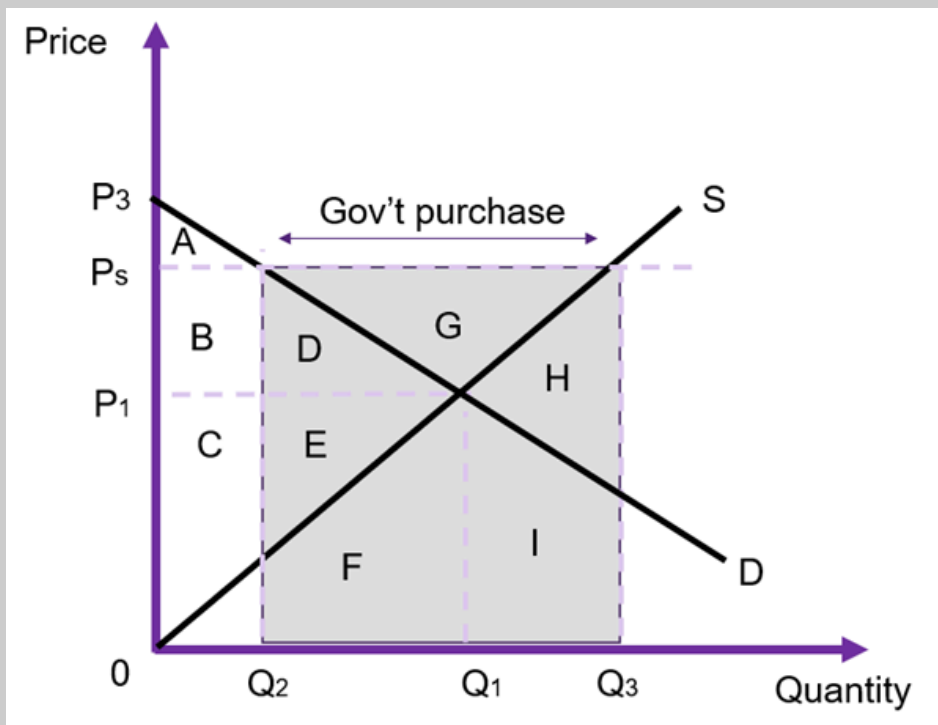


Figure 6.25:  
Government  
Intervention using  
a Price Support

Table 6.4: Surpluses Before and After a Price Support

	Before Price Support	After Price Support
<b>Consumer Surplus</b>	A+B+D	A
<b>Producer Surplus</b>	C+E	B+C+D+E+G
<b>Government Surplus</b>		– (D+E+F+G+H+I)
<b>Total Surplus</b>	A+B+C+D+E	A+B+C-F-H-I



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## Drawing it All Together – Changes in Social Surplus and CBA

At this point, we have reviewed and developed our understanding of the players in the input and output markets related to cost-benefit analysis. This chapter identified how we can use the change in total social surplus to evaluate a policy or project. Taking a public sector approach to interventions, we introduced the role of government in influencing a market to improve social welfare. Under these circumstances we can now evaluate whether a project is worthwhile based on the changes in social surplus across input and output markets involved. Consequently, we end this chapter on the following equation:

$$\begin{aligned}
 \Delta SS &= \Delta SS_{output} + \Delta SS_{input} \\
 &= \underbrace{\Delta SS_{output}}_{\Delta CS + \Delta PS + \Delta GS} + \underbrace{\Delta SS_{input}}_{\Delta CS + \Delta PS + \Delta GS}
 \end{aligned}$$

(6)

## Case Study: Eurovision Song Contest and Economic Surpluses

[This paper by Fleischer and Felsenstein \(2002\)](#) provides insights to how economic surpluses can be used in a cost-benefit analysis. The authors evaluate the benefits and costs associated with Israel hosting the 1999 Eurovision Song Contest. The goal of the analysis was to capture tangible and intangible aspects of Israel hosting the event. The authors calculate the producer surplus, consumer surplus, and government expenditure. The process includes estimating the demand curve (WTP) to calculate the consumer surplus and identify the opportunity cost of diverting resources from their normal uses towards the broadcasting of the contest.



Figure 6.26: 2018 Eurovision Song Contest Grand Final. “[File:ESC2018 – Israel 08.jpg](#)” by Dewayne Barkley, EuroVisionary is marked with [CC BY-SA 4.0](#).

## Revision



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## Summary of Learning Objectives

1. Allocative efficiency occurs automatically in a competitive market at the point where marginal benefit is equal to marginal cost. At this point, no one individual can be made better off without making someone else worse off. Consequently, any project that has a net social benefit greater than zero improves efficiency.
2. Kaldor-Hicks compensation criterion states that a policy is more efficient if there is a net gain to society as this enables compensation between winners and losers of a project, resulting in a net gain to society. When compensation occurs, it leads to an *actual* Pareto improvement.
3. The demand curve is equal to the marginal benefit curve in an efficient market. The demand curve represents the willingness-to-pay. The supply curve is equal to the marginal cost curve in an efficient market. The supply curve represents the opportunity cost of production. The market equilibrium is where demand is equal to supply ( $MB=MC$ ).
4. Governments can implement policies that intervene in an output market. In these instances, we can use the willingness-to-pay to measure the benefits of the policy.
5. Governments can implement policies that intervene in an input market. In these instances, we can use the opportunity to measure the costs of the policy.

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# PART 3: RECONCILING CBA AND MICROECONOMIC FOUNDATIONS

This part combines microeconomic foundations and cost-benefit analysis to evaluate policies, projects, or programs.

In this section, we discuss pricing using distorted markets, dealing with uncertainty and evaluating distributional impacts. We also cover ethical and social aspects of cost-benefit analysis as part of decision-making.



# CHAPTER 7: INTRO TO PREDICTING AND MONETISING

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## Learning Objectives

After completing this chapter, students should be able to:

1. Understand the difference between prediction and monetisation.
2. Understand the process of predicting and monetising where appropriate.
3. Identify sources of bias in predicting and monetising impacts of a CBA.
4. Describe methods for predicting impacts using benefit transfers and their advantages and disadvantages.
5. Identify when to utilise a shadow price.

## Where are we at?

At this point we have developed an understanding on how to monetise impacts in efficient markets. However, we have yet to discuss and implement valuations for “non-market” goods and services and market distortions. Specifically, we want to be able to evaluate market failures and market distortions and capture them in the analysis. This section will look at the various ways we can identify **shadow prices** and implement those shadow prices in a cost-benefit analysis.

### Key Concept – Shadow Price

A shadow price is an estimated monetary price used to value an item, good, or service that is not traded on a market, or the market price does not reflect the true value.

## Circumstances that Require Shadow Prices

Shadow prices in cost-benefit analysis are required to ensure we capture the true social value in a cost-benefit analysis. Shadow prices are required in three situations:

- Absence of a working market – for example, there is no market for noise pollution and therefore if we are accounting for noise pollution in a CBA, we would need to estimate a price for noise.
- Market failures – these create inefficiencies in markets which results in the market price not reflecting the true value of the good or service. There are four key market failures:
  - o Public Goods
  - o Externalities
  - o Information Asymmetry
  - o Uncompetitive Market Structures
- Distortions – market distortions are due to government interventions. When the intervention is not corrective and is instead distortive, we need to adjust the prices used to value the good or service in a CBA. For example, taxes, subsidies, quotas, tariffs, price ceilings, price floors, and regulatory other interventions are all examples of distortions (covered in [Chapter 8](#)).

If we face any of these situations in our CBA, it complicates the estimation of the social prices required. Therefore, we need to adjust the willingness-to-pay or the opportunity costs to account for these price failures in the social cost-benefit analysis. The goal of this chapter is to discuss how to start the process of predicting and monetising impacts at a preliminary level, before deep diving into shadow pricing. Specifically, this chapter focuses on benefit transfers which involves drawing on the existing literature or research.

## Predicting and Monetising

One of the key things we need to start with is predicting and monetising impacts in a policy, program, or project. So far, this process has been implicit. This chapter covers prediction and monetisation in a more explicit framework.

Prediction relates to the process of identifying the impacts of the project, now and into the future. This includes identifying whether impacts are considered benefits or costs, and the duration the impacts are expected to occur. Monetising is the process of quantifying the impacts in monetary terms, specifically in a common currency. Consequently, there is a difference between predicting and monetising that is essential in completing a cost-benefit analysis.



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If predicting and monetising impacts is done inappropriately, the result can significantly impact the net present value (and subsequently the estimated net social benefit). Hence, we need to be aware of the three major sources of **errors** in a CBA that create bias:

## (1) Omission Error

Omission error occurs when an impact is excluded from the CBA. If the cost or benefit excluded is substantial, it prevents the CBA from comprehensively evaluating the policy or project. When considering potential omission errors, an analyst should reflect on the size of the impact and whether exclusion of the impact would significantly change the sign of the net social benefit. This is an issue if the decision-maker is seeking to maximise the use of available resources, as omitting an important impact will introduce bias into the estimates.

Omissions errors are one of the most common errors when evaluating a policy or project – whether it occurs accidentally, or on purpose (intentional exclusions). In reality, most CBAs are incomplete because significant costs and benefits are not included in the process of predicting and monetising, leading to inaccurate and/or misleading results.

## (2) Forecasting Error

Forecasting error occurs because we cannot predict the future with certainty. Each policy or project that is evaluated in a CBA has a time horizon into the future. It is difficult to know exactly what events will happen in the future. We can only truly know what has happened in the past and in the present. This shows how the use of ex-post CBA can be a useful tool in evaluating whether a past project met the goals and provides a learning opportunity for future ex-ante CBAs.

Forecasting errors also include psychological biases. Often CBA analysts can be overly optimistic in predicting and monetising impacts inflating the net social benefit. A series of empirical studies have found there is a tendency for CBA to overestimate the social gains from large projects. It has been found that



overestimation of future use benefits and underestimation of costs are common when conducting CBA (e.g. Flyvbjerg 2007). Hence, evaluation of social policies using CBA tend to be pessimistic, excluding offsetting behaviours or unintended consequences. Whereas infrastructure projects tend to be optimistic which results in the costs being underestimated.

### (3) Valuation Errors

Valuation errors are caused by incorrect monetary valuation of the costs or benefits of a project. If the market price does not provide a true reflection of the value of a good or service – it is not valued correctly. Additionally, we may lack confidence in our estimates for the shadow price when we are unable to rely on a market to provide a value for the good or service. In this case to reduce valuation error, we need to ensure the shadow price is estimated appropriately. For example, if we need to value the loss of wildlife habitat, national pride, or public safety for the NPV to be correct the shadow prices must reflect the true value of these aspects in the CBA.

When attempting to provide a shadow price for a novel and relatively new good or service, there is no basis for making a confident comparison on the valuation of the shadow price. This increases the likelihood of a valuation error occurring.

### Why Are Analysts Concerned with Bias?

The idea is simple. If an analyst knows where the sources of bias are coming from it is possible to anticipate the errors. This provides the opportunity to consciously “de-bias” the estimates in the project and ensure the calculated result reflects the true impact of the policy or project.



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## Benefit Transfers – Predicting and Monetising

Now we turn to using benefit value transfers as a method of predicting and monetising impacts. Benefit transfer is the process of using information estimated in existing, already completed studies and transferring

the information into the current policy or project under evaluation.<sup>1</sup> The idea of using benefit transfers is quite simple – *there is no need to reinvent the wheel!*

CBA analysts can take advantage of the past research efforts of others to predict impacts and utilise monetary prices for goods and services not traded on markets. Benefit value transfers involves using previously estimated shadow prices in a CBA project under consideration. These can often be called “plug-in” values (Boardman et. al., 1997). Many important shadow prices have been estimated, some multiple times – hence it may not be the best use of time and resources for an analyst to estimate the same shadow prices. This is especially useful for impacts like safety, the value of a life, and carbon emissions- shadow prices exist for these impacts due to a significant body of academic literature and research.

There are 4 essential steps to benefit transfers:

**Step 1** – identify whether existing studies or values can be used as part of the transfer method.

**Step 2** – decide whether the existing values from the study are appropriate for use in the CBA under consideration.

**Step 3** – evaluate the quality of the research being used as part of the transfer.

**Step 4** – make any appropriate adjustments to reflect the true value of the impact under consideration in the CBA.

Benefit transfers are a great starting point for identifying and valuing impacts.

## Methods for Predicting

### (1) Incremental Analysis – Relative to the Status Quo

This method does not use benefit transfers, instead it builds on what was discussed in [Chapter 5](#).

As we have discussed in the past, it is possible to conduct an incremental analysis relative to the status quo. This is one method of identifying and predicting the impacts of a policy. If impacts are the same under the status quo and the alternative policy – it is not necessary to predict and monetise these impacts as they are not expected to change. For example, suppose a retail store is considering extending its closing hours from 5pm to 6pm. There is no change in the resources used, however the incremental costs (additional wages paid) and additional benefit (additional sales made) can be accounted for in this method to simplify the prediction process.

---

1. There are many types of benefit transfers. In this chapter we are considering only transfers involved in predicting and valuing impacts. For more examples of benefit transfers in CBA refer to [this guide by Openness](#) under the section “Introduction”. You do not need to know these for this course

## (2) Using Current Ongoing Policies or Projects

Similar to an in-medias res CBA, we can predict impacts of a policy or project based on trials or policies implemented by others. This is particularly useful when a policy under consideration is being trialled elsewhere. By evaluating the benefits and costs based on an ongoing policy, it provides the opportunity to determine if the policy in place should be continued, terminated, or replicated. It also serves as a basis for providing inferences about the impacts of ongoing policy. For example, “lockout laws” were trialled in Newcastle NSW. When looking at the predicted costs and benefits based on the ongoing policy in Newcastle, cities such as Brisbane and Sydney implemented and replicated the lockout laws as a method of reducing alcohol related violence. The idea of using this method allows a trial phase for the project and once data on the policy is available, we “look back (make inferences) to look forward (make predictions).”

It is important to note that when predicting impacts based on current policies, the best inference comes from experimental data with the assignment of participants into treated and control groups. This is often used when predicting the impacts of training programs (e.g., work for the dole) and welfare programs (e.g., universal basic income).

## (3) Predict On the Basis of a Similar Policy or a Series of Similar Policies

An analyst can also predict impacts based on a similar policy or a series of similar policies that are comparable to the intervention being analysed. The value of the predicted impacts of previous policies to an analyst will depend on how close the previous policy matches to the project under consideration and how well the original evaluation was conducted. When predicting impacts on a single project or a few similar projects we should ask the following questions:

1. Does the policy have the same underlying model?
2. How closely do the details of the policies conform?
3. What is the quality of the evaluation or method used in the similar policy?

It is important to note that there are sources of bias when using a single policy or a few similar policies as predictions of the effects: (1) if the research is academic in nature, we can be subject to the positive publication bias of academic journals. Often academic journals only publish positive and/or statistically significant results, (2) non-published or private sector projects are often not reported to the general public and therefore we may not have all available information on predicted impacts which may introduce bias into our assessment of the project under consideration, and (3) there may be optimism bias in the similar published policy that predicted over-optimistic results, or may have an element of bias in the impacts included in the evaluation (this comes back to the errors mentioned in [Predicting and Monetising](#)).

## (4) Utilise Available Meta Analysis

Where possible, it is useful to use meta-analyses of similar policies to predict impacts of a policy under consideration. A meta-analysis is a study that uses a series of previous studies – highlighting the differences and similarities. This approach allows us to draw information from multiple resources or research to reduce the overall reported bias in predicting the impacts of the project under consideration.

Meta-analyses are useful because of the they:

- Provide a deep and comprehensive identification of relevant past research.
- Often standardise the effect size to a common metric such as dollars, percentages, or standard deviations to enable comparisons and applications across different disciplines.

### Meta-analysis and Elasticities

Economics often relies on elasticities. Consequently, elasticities are often a point of evaluation for meta-analysis. Elasticities measure of the responsiveness of a variable to changes in another variable. Having information on generic elasticities or specific elasticities will allow for prediction of impacts for a policy under consideration. In the absence of relevant policy evaluations, it is possible to predict impacts using elasticities. For example, meta-analyses are available for the price elasticity of fuel, residential water use, electricity, and cigarettes. These elasticities can be used for predicting impacts for policies related to pollution, health, etc. Elasticities have been used a lot in environmental and social interventions such as air pollution, noise pollution, environmental conservation, and drug interventions. Elasticities effectively allow an analyst to estimate the willingness-to-pay for a policy or project without starting from scratch.

### Limitations of Meta-analysis

It is important to note that with meta-analysis, the result is often looking at the average of results. This may not be the best fit for the project under consideration. Often the research that matches the project under consideration best may be overlooked. Therefore, when utilizing meta-analysis as a foundation for prediction or for shadow pricing, ensure you delve deep into the cited papers.



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## (5) Consult Experts

When the cost-benefit analysis under consideration is novel, it is not often possible to find existing research to support the process of predicting and monetising impacts. In these cases, it is often a good idea to consult experts in the field. These experts can make predictions based on a plausible range of outcomes based on tacit knowledge developed from their experience with the subject field.

With this method, there is likely to be bias – either overestimating or underestimating impacts as there are too many unknowns. Consulting multiple experts may be preferential, followed by deriving a mean or median prediction for inclusion in the project under consideration.

## Monetising

After we have predicted the costs and benefits associated with a policy, program, or project, we need to monetise the predicted impacts. Monetising involves quantifying the predicted costs and benefits in a common currency or metric. This allows for direct comparison of the costs and benefits associated with a project. When it comes to monetisation, we deal with market and non-market costs or benefits. Market based monetisation is simple. As we have seen so far, we can use the market price as an input value in a CBA following the fundamental principles of willingness-to-pay and opportunity cost we have learned so far. When markets are distorted or missing, an analysts must find appropriate shadow prices, the problem of quantification is much more challenging.

## Monetising Impacts in Missing Markets

We finish this section by looking at the use of shadow prices. It is possible to monetise impacts over the life of a project using a shadow price that was estimated by someone else. Consequently, benefit *value* transfers can also be used to *monetise* impacts. For common non-market goods and services, research exists on the appropriate shadow prices. Benefit value transfers can also be used for distorted markets, providing a useful alternative approach for estimating the value of a good or service.

Benefit value transfers can be used in the following circumstances:

### (1) The absence of markets for a cost or benefit.

When a market does not exist for a good or service, we might consider the use of prior research to find appropriate shadow prices. For example, consider a road improvement project which is estimated to result in a reduction in fatalities on a section of road which averages 10 deaths per year. The problem occurs when we want to value the lives saved from the road improvement. What value would you apply to a life? There is a significant amount of research on this area that the analyst can draw upon.

## (2) No appropriate market value exists due to market failure or distortions.

When the market value does not reflect the true value of the good or service, we may consider using a shadow price. For example, if we wish to estimate the value of some national parkland. The current market value of land is not reflective of the value of national park land because of the wildlife habitat, resources, or geographical location is not accounted for. Consequently, the market value therefore represents an inappropriate valuation of the parkland. However, parkland and similar recreational facilities have been widely researched and shadow prices could be borrowed as “plug-in” values for the CBA.

## On a Final Note.

Take advantage of the research that is available to predict impacts and estimate shadow prices. Many important shadow prices have been estimated in the literature and often have meta-analyses available. Consider the quality of the research, the goals of the evaluation, the methodology, and whether the research is sufficiently similar to the project under consideration. It is important, when using benefit transfers for impacts or values, we should consider how closely the impact or shadow price fits the project being evaluated.

It is important to emphasize that *benefit transfers can perform no better than the quality of original studies*. If benefit value transfers cannot be used for shadow pricing, we can use alternative market pricing, or non-market valuation method using stated and revealed preferences. These will be covered in [Chapter 12](#).

## Revision



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## Summary of Learning Objectives

1. Prediction relates to the identification of the impacts that must be accounted for in a CBA. Monetisation involves quantifying the impacts in monetary terms.
2. Predicting and monetising impacts is a crucial step in cost-benefit analysis. If we do not predict and monetise the impacts we can overestimate or underestimate the net present value or net social benefit.
3. There are three types of errors: (1) omission error, (2) forecasting error and (3) valuation error. Omission error is caused by excluding relevant impacts. Forecasting errors are related to the prediction of impacts over time. Valuation error is inaccurate estimation of the prices used in the CBA.
4. We looked at 5 methods of predicting impacts: incremental analysis, using ongoing policies, using previous similar policies, meta-analysis, and the consultation of experts.
5. Shadow prices must be used when the market price does not reflect the true value of the good or service.

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- Boardman, A. E., Greenberg, D. H., Vining, A. R., & Weimer, D. L. (1997). "Plug-in" shadow price estimates for policy analysis. *The Annals of Regional Science*, 31(3), 299-324.
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# CHAPTER 8: A SOCIAL PERSPECTIVE TO CBA

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## Learning Objectives

**After completing this chapter, students should be able to:**

1. **Identify economic efficiency and its challenges in practical applications.**
2. **Understand the role of shadow prices for economic efficiency in CBA.**
3. **Identify and utilise relevant shadow prices using adjusted observed prices in distorted markets.**
4. **Demonstrate the difference between corrective and distortionary taxes/subsidies.**

As we have seen in [Chapter 5](#), the investor perspective CBA is fairly easy calculate. An analyst identifies the revenues and expenses to evaluate the opportunity cost to the investor.

The social perspective is harder to implement in CBA. Calculating social benefits and costs can be complex. Market prices often do not capture the social benefit and/or social costs associated with production or consumption of a good. Therefore, we need to consider:

- 1) Impacts on input and output markets ([Chapter 6](#)).
- 2) Shadow pricing using market prices or benefit transfers ([Chapter 7](#) and [8](#)).
- 3) The use of non-market valuation methods when a market does not exist ([Chapter 12](#)).<sup>1</sup>

This chapter focuses on how to attain a price for goods and services in markets that are distorted. In

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1. Chapter [10](#) and [11](#) deal with key issues relating to social cost-benefit analysis in terms of uncertainty and ethical decision-making.

[Chapter 6](#), we looked at how markets can be used to evaluate costs and benefits involved in an intervention or project through willingness-to-pay and opportunity cost. In [Chapter 7](#), we discussed how to initiate the process of predicting and monetising impacts using the available literature and research (through benefit value transfers). However, we have yet to determine how to address market failures and market distortions associated with CBA projects under consideration.

Market failures are one of the most important aspects of social cost-benefit analysis. We know that *market prices may not reflect the true value of an item, good, or service*. Consequently, we may need to use shadow prices to capture the true value of the goods or services in question. This chapter focusses on shadow pricing using distorted markets and incorporating the result into the social perspective to cost-benefit analysis.

## Returning to Efficiency

From the point of view of society, the requirement for economic efficiency is the marginal social benefit (MSB) is equal to the marginal social cost (MSC). In a perfectly competitive market, in the absence of distortions:

Demand = Marginal *Social* Benefit

Supply = Marginal *Social* Cost

Therefore, the efficiency condition holds as  $D(MSB) = S(MSC)$ . In this case, consumer and producer surplus is maximized. Consequently, total social surplus is maximized. It is allocative efficient and there is no potential Pareto improvement (see [Figure 8.1](#)). i.e., no individual can be made better off without making another party worse off.

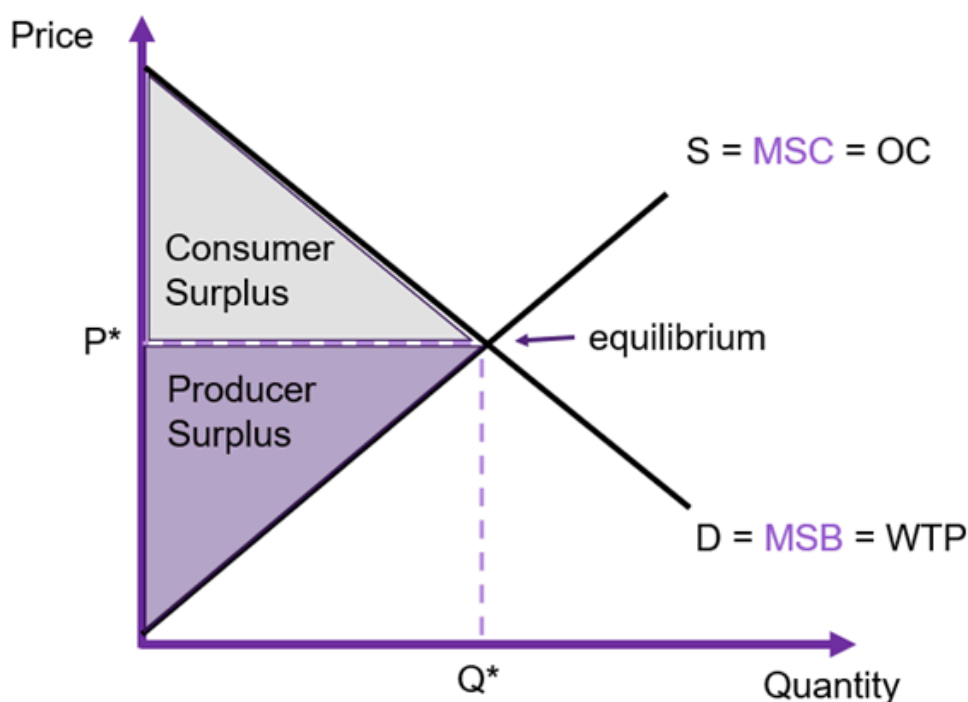


Figure 8.1:  
Competitive  
Market  
Equilibrium.

To understand allocative efficiency in the market we can consider the impact of inequality between marginal social benefit and marginal social cost. If  $MSB > MSC$ , it makes sense to allocate more resources as both the consumer and producer would gain additional surplus by doing so. The opposite is true when  $MSC > MSB$ , it makes sense to allocate less resources to the market as the cost exceeds the benefit.

In the context of cost-benefit analysis, if the whole economy is perfectly competitive and all markets were subject to the invisible hand, private firms would undertake all projects where the net benefit is greater than zero. Hence, no unproductive project would ever be undertaken by an investor. This is because firms are profit maximisers. By maximising their own profits, the firms would also maximise all benefits to society. In this instance there would be no role for the government as an economic entity as all potential public sector projects would be undertaken by the private sector.

More specifically, from a societal perspective there would also be no need for social cost-benefit analysis as the economy would achieve allocative efficiency without assistance of a government. All social costs and social benefits would be accounted for in this perfectly competitive world. However, we know that no society or economy is perfectly competitive, and governments often intervene in markets for many reasons including but not limited to:

- correcting market failures
- improving the allocation of scarce resources
- improving the welfare of society
- redistributing welfare gains/ income

### Key Concept – Competitive Markets

*So why does economics focus on perfectly competitive markets? Especially when perfectly competitive markets are few and far between in the real world?*

Economists use perfectly competitive markets as a benchmark for evaluation purposes. Having a benchmark allows for a point of comparison that we can compare observed results and outcomes against. Consequently, having a benchmark for CBA provides opportunities to identify potential Pareto improvements in the distribution of surpluses.



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## Efficiency and Shadow Prices

For the market to be efficient, there should be no externalities, no uncompetitive market structures, no information asymmetries, and no requirement for public supply of a good or service by a government. When one or more of these conditions exists, market failure exists and there is a misallocation of resources. Market failure implies the market price does not reflect the true value of the good or service – the marginal social benefit is *not equal* to the marginal social cost. In the instance that a market is inefficient, a CBA analyst needs to identify the appropriate price that reflects the true value of the item, good, or service. This is the shadow price for the evaluation of the policy under consideration.

If we do not use the appropriate shadow price, the results of the cost-benefit analysis may overestimate and underestimate the net social benefit (NSB). This is problematic as NSB is used to determine which projects we should undertake, leading to the potential for incorrect decisions. The goal of the social perspective CBA is to calculate the aggregate net social benefit to ensure the efficient allocation of resources – addressing the market failure. However, the distribution of the benefits and costs is not considered as part of this perspective. This is a consequence of the Kaldor-Hicks compensation criterion.

The Kaldor-Hicks compensation criterion was defined in [Chapter 6](#) – when the net social benefit is greater than zero there is an ability to compensate losers with gains from winners through the transfer of benefits, resulting in a net gain to society. The Kaldor-Hicks criterion is the foundation for the net benefit criterion for decision-makers to only adopt policies with a positive net social benefit/net present value (Boardman et.al., 2001, 31). Compensation may not actually occur, but the ability for compensation provides a potential for Pareto improvement. Consequently, the Kaldor-Hicks criteria is a looser version of the potential Pareto improvement rule. To effectively capture the ability for potential compensation, all inputs to the CBA must represent the *true value to society*. Therefore, we often need to estimate shadow prices.

In this chapter, we discuss the evaluation and adjustment of market prices to establish the appropriate shadow prices. The shadow price can be found by adjusting the observed market values to ensure the willingness-to-pay (WTP) or opportunity cost (OC) reflects the value of the good or service. Specifically, we will look at shadow prices for input and output markets including those experiencing distortions via taxes, subsidies, government regulation, or market imperfections. When a market is distorted, there are two prices; (1) the price paid by buyers and (2) the price received by sellers. The goal is to determine which of these prices we should use in the cost-benefit analysis as the shadow price. Consideration for goods or services not traded on markets are covered in [Chapter 12](#).



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## General Rules for Distorted Markets

At this point we highlight the general rules for shadow pricing in distorted markets. Firstly, we require identification of whether the intervention impacts an input or output market. Secondly, we need to identify what happens to the quantity traded: does the availability increase or is there a diversion of production/consumption on the market in question. Note that this often depends on the assumptions being made about the intervention.

General rules for input (costs) and output (benefits) markets are identified and outlined below.

### Output markets

Output markets are those where the finished products are being purchased. In cost-benefit analysis, often output markets under consideration include monopoly producers, goods and services for consumption such as education or roads and transportation etc.

#### Rules:

- If the intervention causes the availability of the *output* to *increase* – use WTP
- If the intervention *decreases* the availability of the *output* for use by others to (diverting use) – use OC

### Input markets

Input markets are also known as factor markets. These markets include those resources that the government, firms, or business need to purchase in order to produce goods or services for purchase (the output). Examples include land, labour, capital, and raw materials.

#### Rules:

- If the intervention causes the availability of the *input* to *increase* – OC
- If the intervention *decreases* availability of the *input* for use by others (diverting use) – WTP

## Distorted Markets and Shadow Pricing Examples

We will now consider the competitive market as illustrated in Figure [8.1](#) in comparison to:

1. Monopoly
2. Distortive Taxes

3. Distortive Subsidies
4. Information Asymmetries
5. Public Goods
6. Externalities
7. Corrective Taxes and Subsidies
8. Monopsony
9. Labour Markets with Minimum Wages

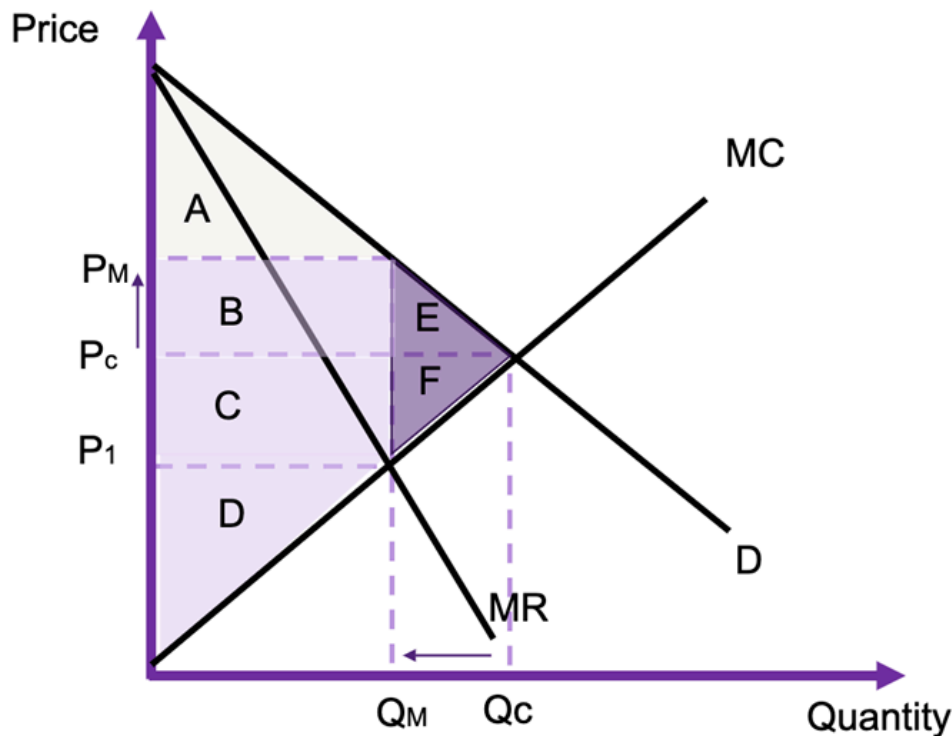
By evaluating the price paid by buyers and the price received by sellers we can identify which price is appropriate for use as a shadow price. We can then apply the appropriate shadow price to the Social CBA Perspective to ensure consistent estimation of the net social benefit. The examples provided are not exhaustive of market distortions we must account for, however the range of examples provided in this chapter allow for better understanding on how to apply the rules outlined [above](#).

## (1) Monopoly

A monopoly occurs when there is only one seller of a good or service on a market. A monopoly is a price setter in an output market. Like all firms, a monopoly chooses to price at the point of profit maximisation ( $MR = MC$ ). However, in comparison to a perfectly competitive market the monopoly faces a downward sloping marginal revenue curve as monopolies are price makers.<sup>2</sup> When the market is a monopoly, the seller must lower the price to sell an additional unit, reducing the marginal revenue (the additional gain in revenue from selling one more unit). Consequently, the marginal revenue (MR) curve lies below the demand curve, and the firm will maximise its profits when marginal revenue is equal to marginal cost ( $MR = MC$ ).

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2. Rather than a price taker which results in the marginal revenue equal to the price.

Figure 8.2:  
Monopoly Output Market.

If the market is perfectly competitive, the equilibrium price and quantity would be  $P_C$  and  $Q_C$  respectively as illustrated in Figure 8.2. Under the distorted monopoly market, the monopolist will choose to price at  $P_M$  and quantity  $Q_M$  to maximise their profits.  $P_M$  is the price received for producing  $Q_M$  units on the market and  $P_1$  is the cost of producing this level of output. This increases the producer surplus and reduces the consumer surplus in the market. The monopoly also results in a deadweight loss the size of the purple triangles E and F. The rectangle B is a transfer from consumers to producers as part of the profit maximisation process of a monopoly.

From a cost-benefit analysis standpoint, determining which price to use for the evaluation of the impacts is much more challenging:

- If the government is *purchasing* the good from the monopoly output market, the government would be hijacking the consumption directly from private consumers. Therefore, the willingness-to-pay should be used to represent the true value of the intervention. Consequently, we would use  $P_M$  as the shadow price. This is because resources would be taken away directly from other consumers in the market (diverted uses).
- If the government intervention increases the *production* of the monopoly output, the opportunity cost should be used as the shadow price. Hence the shadow price used for the intervention would be reflected by marginal cost curve (at point  $P_1$ ).
- If the government intervention increases the production of a monopoly output is increased, *but not by the full amount* of the intervention, the shadow price should lie between the  $P_M$  price and the marginal cost (price  $P_1$ ). In previous chapters, we have suggested taking the average of the two prices.



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## (2) Distortionary Taxes

Taxes can be direct or indirect. Direct taxes are those imposed on income or profits. The person paying the tax is the one who carries the burden of the tax (for example, income tax is paid by those who receive income). In comparison, indirect taxes are imposed on goods and services. With indirect taxes, the incidence of tax is distributed between both the buyer and seller. The distribution of the burden depends on the relative elasticities. Examples of indirect taxes include GST, customs fees, duties etc. CBA often deals with indirect taxes in the evaluation of the market price of a good or services. There are two types of indirect taxes we deal with (1) fixed per unit taxes and (2) ad valorem taxes.

### Fixed Per Unit Taxes (Specific Taxes)

If the tax is a fixed amount per unit, it is a flat rate tax on each unit of output. If the tax is a fixed amount per unit, the change in the supply curve is a parallel shift as illustrated in Figure 8.3. The difference between  $S$  and  $S_{tax}$  is the amount of the tax.

When the tax is distortionary, there are two prices – one paid by the buyer  $P_b$  and one received by the seller  $P_s$ . We can also observe that regardless of the type of tax, the quantity traded on the market decreases due to the higher price faced by the buyer.

We can specify the linear function for the price paid by consumers as a function of the price received by the sellers and the tax rate as:

$$(1) P_b = P_s + t$$

where  $t$  is the per unit tax.



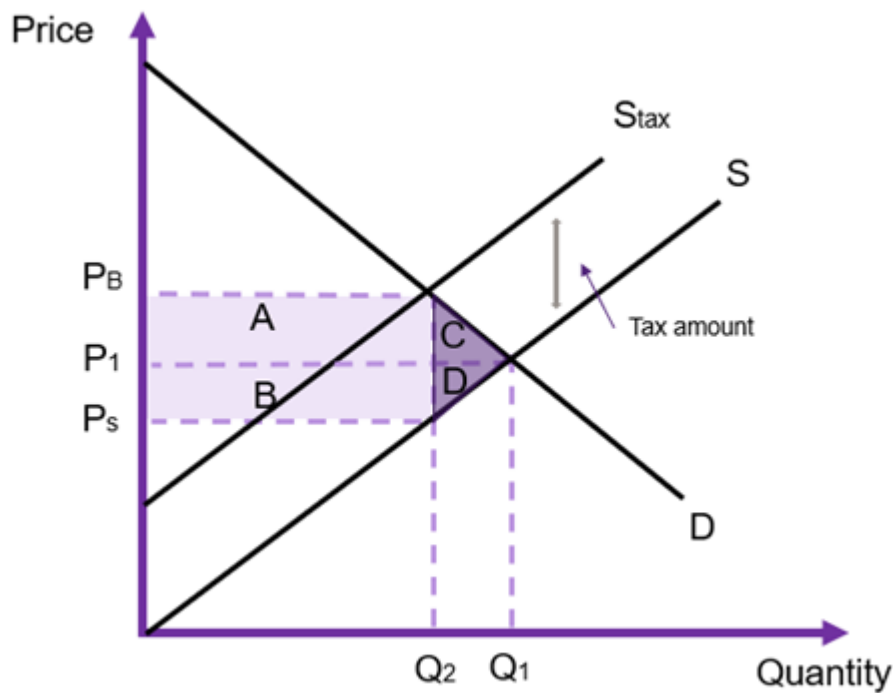


Figure 8.3: Impact of a Distortive Flat Per Unit Tax

Figure 8.3 shows taxes drive a wedge between the price received by the buyer and the price paid by the seller, such that  $P_b > P_s$ . We also note that the equilibrium price increases from  $P_1$  to  $P_b$ , however the price received by the seller is  $P_s$  which is below the initial equilibrium price. The tax is collected as a revenue stream for the government equal to the rectangle  $A + B$  which can be found by taking the difference between the buyer and seller prices and multiplying by the quantity traded after the tax is implement.

There is also a reduction in the producer surplus equal to the area of  $B$  and  $D$ , along with a reduction in the consumer surplus equal to  $A$  and  $C$ . Consequently, we can identify the triangles of  $C$  and  $D$  is a deadweight loss caused by the distortive tax (hence the distortion of a previously efficient market!). The area of  $A$  is the incidence of tax paid by the buyer and the area of  $B$  is the incidence of tax paid by the seller. These are not necessarily equal and depend on the relative elasticities of the demand and supply curves.

## Example 8.1

### Example: Calculating a Flat Tax

Assume that the market demand curve is linear and is expressed as:

$$q_d = 50 - 0.5p$$

And the supply curve is given by:

$$q_s = 2p$$

Solving for the market equilibrium before the imposition of a tax give an equilibrium price of \$20 and an equilibrium quantity of 40 units.

If there is a tax of \$2 per unit, we must shift the supply curve up to imply a \$2 increase in the cost of production. Therefore, the new supply curve:

$$q_{stax} = 2p - 2$$

Equating the demand and the supply curve after the tax gives

$$50 - 0.5p = 2p - 2$$

$$52 = 2.5p$$

$$p = 20.8$$

The new equilibrium quantity is therefore  $q_d = 50 - 0.5(20.8) = 39.6$  units

From this information we can observe the following:

- The tax revenue received by the government is equal to  $39.6 \text{ units} \times 2 = 79.20$ .
- The equilibrium price after tax has increased from \$20 to \$20.80. This means that the buyers' price  $P_b$  is 80 cents higher. Consequently, the buyer's incidence of tax is 80 cents.
- The price the seller receives is  $P_s$  is \$18.80. Therefore, the seller pays \$1.20 of the tax (found using the original supply curve).
- The burden of the tax falls on the seller.

You can try graphing the demand and supply curves to calculate the changes in the surpluses.

## Ad Valorem Taxes

An ad valorem tax is a tax that is proportional to the price. In the case of an ad valorem tax, the change in the supply curve is not parallel to the original supply curve as illustrated in Figure [8.4](#).

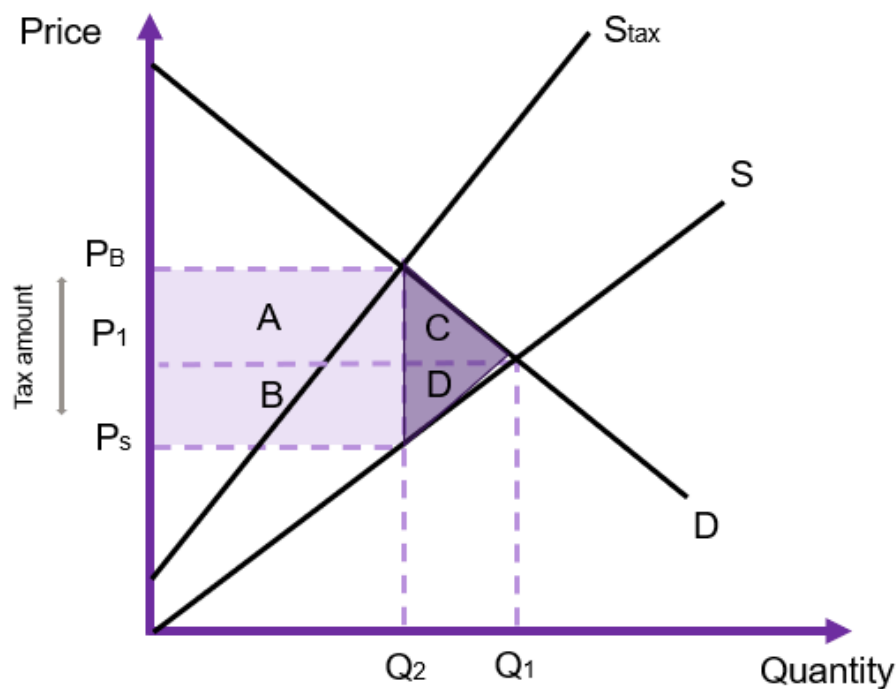


Figure 8.4: Impact of a Distortive Ad Valorem Tax

Again, if the tax is distortive, there are two prices –  $P_b$  paid by buyers and  $P_s$  received by sellers.

For an ad valorem tax, the relationship between the buyer and the seller prices is:

$$(2) \quad P_b = P_s(1 + t)$$

where  $t$  is the proportion of tax paid. As the amount of the tax is proportional to the number of units traded on the market,  $S_{tax}$  is no longer parallel to the original supply curve (seen in Figure 8.4). The impacts of the ad valorem tax on consumer and producer surplus are the same as under the flat (per unit) tax with A representing the burden to consumers and B representing the burden to producers. The deadweight loss is equal to the area of C and D combined.

## How do we determine the appropriate shadow price when the tax is distortive?

The choice of shadow price to use in the CBA depends on the factors affecting the market. Again, we need to identify two key aspects:

- 1) Is the market affected by the tax an input or output market?
- 2) Does the availability increase or is there a diversion of production/consumption (production for inputs and consumption for output markets)

In relation to point 2) we look at whether the quantity traded is diverted from consumers in an output market or whether the use of the goods is diverted from their current use in an input market. If there is no diversion, the intervention is either satisfying the additional demand for an output or sourced from additional supply for an input.

Consequently, the conceptually correct shadow price to be used in the cost-benefit analysis could be  $P_b$  or  $P_s$ , depending on the circumstances.

### Distortive tax in an Input Market.

- If the number of additional units of the input good are produced to meet the increased demand of the input for the project (i.e., supply is increased) – use  $P_s$  (seller price) as it represents the opportunity cost of the additional production.
- If the currently produced units of the input good are diverted from their current use in the economy due to the project – use  $P_b$  (buyer price) as it represents the WTP of the foregone benefit to the users of the input caused by the diverted use.

### Distortive tax in an Output Market.

- If the intervention causes an increase in the availability of the good, that satisfies additional demand on the market – use  $P_b$  as it represents the WTP for the additional output (the benefit to the buyer).
- If the intervention diverts consumption of the output for use by others – use  $P_s$  as this represents the opportunity cost of the consumption of the output foregone.



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In practice, when dealing with distortive taxes and its applications in CBA we often use  $P_s$  for input markets (representing the opportunity cost of production) and  $P_b$  for output markets (representing the willingness-to-pay). For practical applications, it is also important to take into account the marginal excess tax burden. The marginal excess tax burden (METB) measures of the additional loss to society from raising an additional dollar of revenue through the tax, beyond the revenue collected. It represents the deadweight loss associated with the tax. Calculating the METB is complex, involving modelling the behaviour of individuals and firms under different tax scenarios and comparing the resulting economic outcomes to determine the additional loss to society associated with the tax.

## (3) Distortionary Subsidies

Similar to the situation with taxes, we can consider how to correct for market distortions when government subsidies exist on the market. The aim of a subsidy is to lower the price of the good or service for buyers. After applying the subsidy to the market, the price paid by consumers will be less than the initial

equilibrium as shown in Figure 8.5. The supply to customers is represented by  $S_{subsidy}$  which captures the cost of production minus the subsidy paid by the government. Again, there are two prices: one paid by the buyer  $P_b$  and the price received by the seller  $P_s$  and under a subsidy  $P_b < P_s$ . Similar to taxes, the relationship between the price paid by buyers and the price received by the seller can be summarised as  $P_b = P_s - s$  for a fixed subsidy and  $P_b = P_s(1 - s)$  for an ad valorem subsidy. It is important to note that  $P_b$  is lower than the initial equilibrium price of  $P_1$  and  $P_s$  is higher than the initial equilibrium price  $P_1$ . The subsidy also increases the quantity of the good traded on the market from  $Q_1$  to  $Q_2$ .

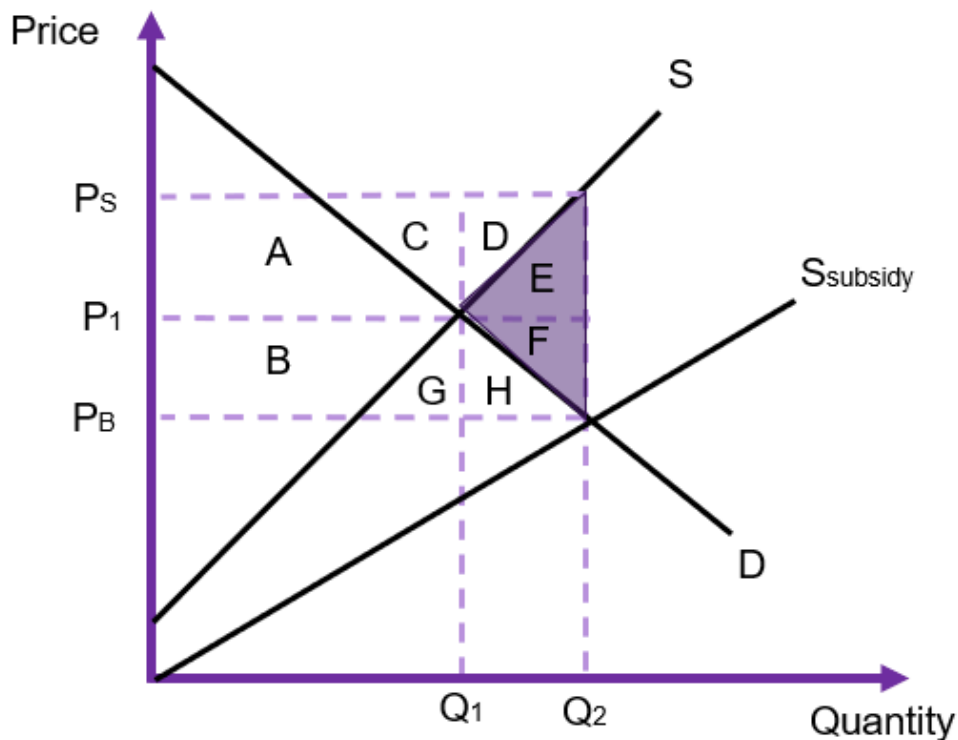


Figure 8.5: Impact of a Distortive Ad Valorem Subsidy

From the implementation of the subsidy, we can see that the consumer surplus increases by the area of B, G and H, due to the reduced price. Producers gain additional revenue in the output from the subsidy equal to A, C and D as the producer now receives a higher price for the good. The increased benefits to consumers and producers are at a cost to the government who has an expenditure equal to the area of A + B + C + D + E + F + G + H. As the quantity of the good on the market has increased and we no longer produce at the socially optimal level, there is a deadweight loss to society of the area of E + F. Again, the relative benefits to producers and consumers of the subsidy depend on the relative elasticities of the supply and demand curves.

## How do we determine the appropriate shadow price when the subsidy is distortive?

The choice of conceptually correct shadow price to reflect the value of the good or service under consideration in the CBA will depend on whether (1) it is an input or output market and (2) whether production/consumption is being diverted from the market. Based on this, the shadow price can be  $P_b$  or  $P_s$  for the subsidy depending on the market under consideration.

### Distortive subsidy in an Input Market.

- If the production (supply) on the market increases to meet the additional demand of the input for the project – use  $P_s$  (seller price – without the subsidy) as it represents the opportunity cost of the additional production.
- If the availability of the input on the market is consequently diverted from their current use in the economy due to the project – use  $P_b$  (buyer price – with the subsidy) as it represents the WTP of the foregone benefit caused by the diverted use. It also represents the price actually paid by the buyers in the market.

### Distortive subsidy in an Output Market.

- If the intervention causes an increase in the availability of the good, that satisfies additional demand on the market – use  $P_b$  as it represents the WTP for the additional output. This price represents the price actually paid by buyers.
- If the intervention diverts consumption of the output for use by others – use  $P_s$  as this represents the opportunity cost of the consumption of the output foregone.

In practice, when dealing with distortive subsidies in CBA we often use  $P_s$  for input markets (representing the opportunity cost of production) and  $P_b$  for output markets (representing the willingness-to-pay) – remembering that the seller price is greater than the buyer price when there is a subsidy on the market ( $P_s > P_b$ ). Furthermore, it is important to note that with subsidies on input markets, there may be flow on effects to output markets. For example, if we consider the effect of a subsidy on fertiliser (an input) and how it affects the output of wheat produced by Australian farmers. The subsidy will impact both the fertiliser and wheat markets. As the government implements a subsidy for fertiliser this will reduce the marginal cost of production for the firm producing wheat. The shadow price for fertiliser would need to be identified based on the market conditions and consequently the changes in consumer and producer surplus on the wheat market would need to be identified to fully capture the impacts of the policy.





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## (4) Information Asymmetry

Information asymmetry is caused by an imbalance in the information between a buyer and a seller, causing one agent in the market to be better informed. Figure 8.6 illustrates the impact of information asymmetry on the market from the perspective of the buyer. When there is information withheld from the buyer the demand curve faced by the buyer would be  $D_{asym}$  – this occurs when the seller has more information on the quality of the good or service than the buyer has. This results in a market distortion where the market clears with consumers paying a higher price and purchase more of the good, above the socially optimal level of output. Obviously, if the buyers are fully informed their willingness-to-pay would be lower. This would result in symmetric information and the demand curve would be  $D_{sym}$  and the market would be efficient. Comparing the situations, if the market faces  $D_{asym}$  there is over production of the good or service as the marginal social benefit is not equal to the marginal social cost which implies the market is inefficient. This creates a deadweight loss of the area B. Additionally, as the market clearing price is  $P_2$ , there is also an increase in the producer surplus equal to the shaded area of A.

Due to the aforementioned impacts, using the market prices under asymmetric information is likely to value inputs or outputs inaccurately in a cost-benefit analysis.

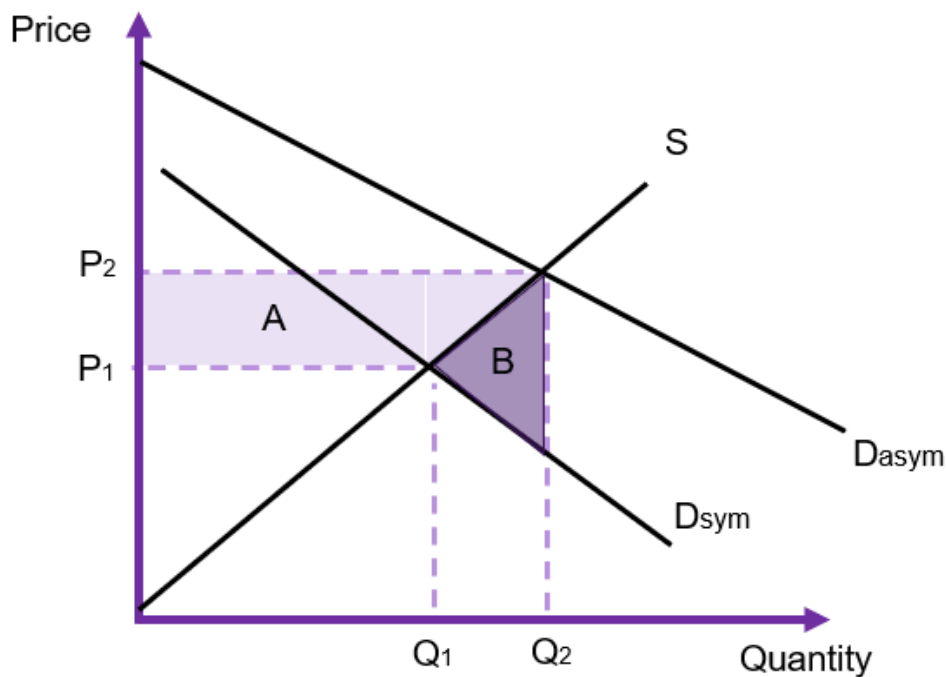


Figure 8.6: Impact of Information Asymmetry on a Market

For the context of CBA, the choice of which price to use as the shadow price depends on the type of information asymmetry and whether the buyer or the seller is the uninformed party, and the type of asymmetric information.

There are many types of information asymmetry in output markets. The three main types often discussed by economists include: (1) search goods, (2) experience goods, and (3) credence goods.

A search good is tangible and measurable (e.g., clothing, furniture). It can be assumed that the buyer of a search good can seek out and verify the required information required before purchase resulting in the market achieving the socially optimal outcome. In this case there is no need for government intervention and the market price will correctly be evaluated at  $P_1$ . In this instance, the distortion should resolve itself and the market price can be used to value the good or service.

For experience goods (e.g., movies, haircuts), information regarding the quality cannot be ascertained before consumption due to subjectivity and the intangible nature of the goods. However, there can often be information shared and searched for after the fact. For example, word of mouth or reviews posted on the internet can be utilised by individuals to reduce the deadweight loss associated with this form of information asymmetry. Lastly, credence goods (e.g., education, healthcare, and other professional services) are intangible and consumers cannot fully observe the outcome relating to the good, even after purchase. This is the more problematic format of asymmetric information, and the determination of the appropriate shadow price is more complex.

## Information Asymmetry and Shadow Prices

Depending on the type of asymmetric information will determine the shadow price used. Often the opportunity cost of search time to reduce information asymmetry and the reduced price from being informed on the transaction gives a net benefit to the consumer of the good that can be calculated (see for



example this paper by [Scott, Scott and Auld from 2005](#) on the benefits of internet searches). Given the complexity of asymmetric information, it is often suggested that government intervention is the preferred method for resolving the distorted market. If a government can intervene, regulate, or provide information for less than the deadweight loss, then net benefits would be positive. If there is an intervention to resolve the incomplete information provided to one party, the price should be equal to the equilibrium price when the demand for the output (or supply curve for input) is represented by  $D_{sym}$  (for example, this would be at price  $P_1$  in Figure 8.6). In CBA, if the government intervenes and provides the uninformed party with the required information it can reduce the deadweight loss. For example, in a second-hand car market the government can require roadworthy certificates which would reduce information asymmetries and therefore decrease the loss to society. Therefore, if the cost of intervention is less than the benefit from the reduced deadweight loss, the project or policy should be undertaken.

Finally, it is worth mentioning at this stage that asymmetric information in input markets is also possible. An example of this is through the labour market where the quality of a worker (the supplier of labour) is unknown to the buyer of labour (the firm). Similar issues arise from asymmetric information in input markets, but one important concept is the costing of interviews and hiring when evaluating a labour (input) market experiencing asymmetric information.



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### Case Study: Volkswagen Emissions Scandal (Diesel-Gate)

Many companies withhold information from the market often engaging in low-risk, high return “moral hazard” behaviours. This is a particularly common issue in economics with many examples relating to car manufacturers.

In 2015, Volkswagen (VW) admitted to installing devices to cheat diesel emissions test. Consumers were led to believe that their cars were more environmentally friendly due to reduced carbon emissions. The VW diesel cars were subsequently marketed as one of the most fuel efficient, reduced emission cars on the market at the time. This “greenwashing” resulted in consumers purchasing cars that were “believed to be better for the environment”. As a result, more VW diesel cars were likely bought and sold at a higher price

than socially optimal. This increase VW's producer surplus and create a deadweight loss to society.



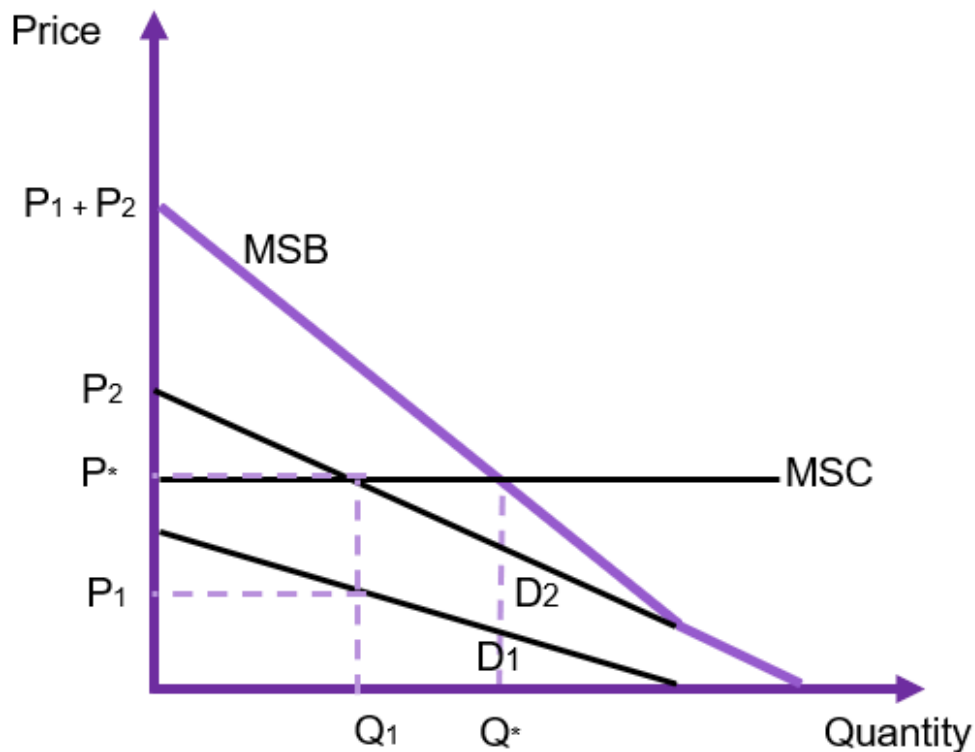
Figure 8.7:  
"Volkswagen Golf  
GTI Cabrio" by  
David Villarreal  
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## (5) Public Goods

Pure public goods have two key attributes: (1) non-excludable, and (2) non-rivalrous. Non-excludable means it is not possible to exclude someone from the use of the good. Non-rivalrous means the consumption of the good by one person does not diminish the ability of another person to consume the good at the same time. Examples of public goods are national defence, law enforcement, air, and street lighting.

Due to the key characteristics of a public good, there is no incentive for the private sector to produce the good or service. Additionally, public goods are subject to the free rider problem as consumers can utilise or consume public goods without paying for them. To determine the marginal social benefit of a public good, the individual demand curves are added vertically, as illustrated in Figure 8.8. This is because a public good is non-excludable, so the marginal benefit is equal to the sum of the individual marginal benefits (i.e., the willingness-to-pay of each person in the market). The resulting curve is known as the kinked demand curve. If  $D_1$  is the demand for individual 1 and  $D_2$  is the demand for individual 2, we add the two demand curves *vertically* together with the intercept equal to the sum of the individual intercepts. This creates a kink in the MSB curve at the quantity where  $D_1$  intersects the demand curve.

Figure 8.8: A Market for a Public Good.



If we assume a constant marginal social cost, and an equilibrium price of  $P^*$  the efficient market equilibrium would be at  $Q^*$ . However, as this is a public good the quantity *actually* produced is  $Q_1$  units at price  $P^*$ . This is the underproduction caused by the provision of a public good.

Public goods are complex by nature, and for practical purposes it is not known exactly what the market for a public goods is like. Shadow prices for public goods will be discussed in detail in [Chapter 12](#), as in most cases there are no markets for “pure” public goods and therefore we cannot evaluate it from the perspective of market distortions. We can however derive the willingness-to-pay using non-market valuation methods.



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## (6) Externalities

An externality is an indirect cost or benefit that impacts a third party not involved in the consumption or production of the good or service. Externalities can be positive (additional benefit) or negative (additional costs). Consumers will purchase the good or service where the marginal *private* cost (MPC) is equal to the

marginal *private* benefit (MPB). In the case of an externality, there is an additional impact that provides a benefit or cost to society.

A negative externality imposes an additional cost to society from the production. This could be in the form of pollution, traffic congestion, noise, etc. Negative externalities result in a marginal social cost that is higher than the marginal private cost, resulting in a negative consequence to society. In the instance the externality is positive, the price of the good on the market does not capture the additional benefits the good or service provides to society. However, there is a positive spill-over effect benefitting society.

The result of an externality is that the market underestimates the social costs or underestimates the social benefits of the good or service under consideration as part of the CBA.

## Negative Externality

In the instance the externality is negative, the price of the good only reflects the marginal private cost of production. There is an additional cost imposed on society known as the marginal external cost (MEC). Consequently, the marginal social cost is equal to the marginal private cost plus the marginal external cost ( $MSC = MPC + MEC$ ). The impact of a negative externality is illustrated in Figure 8.9 below.

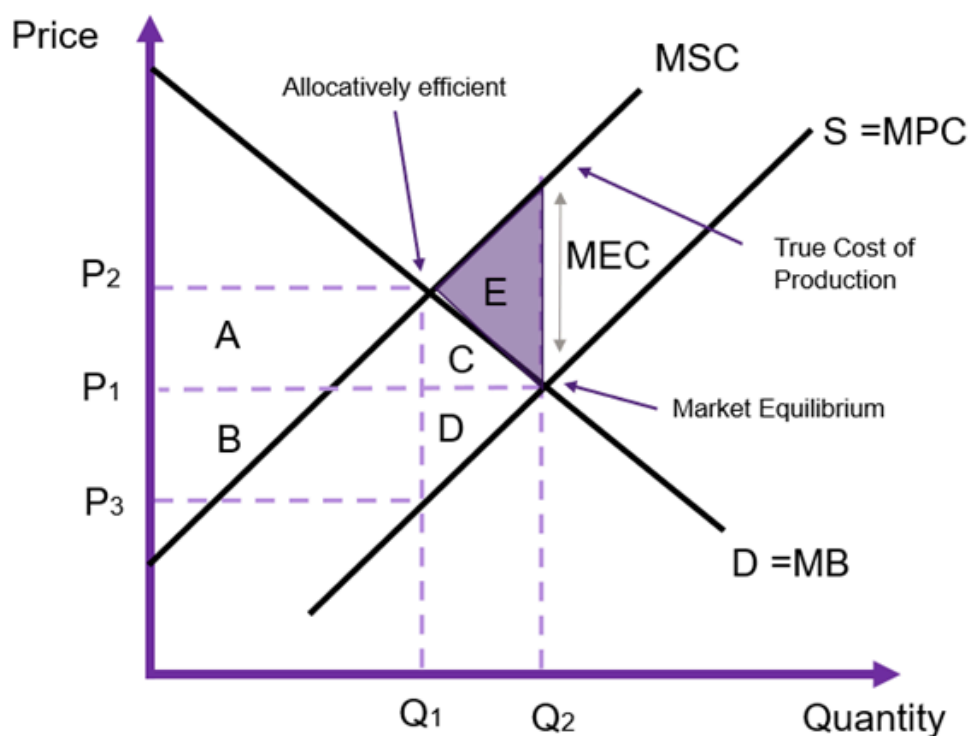


Figure 8.9: Impact of a Negative Externality on the Market.

A negative externality causes a deadweight loss to society caused by the overproduction of the good and service as the marginal social cost exceeds the marginal benefit at the market equilibrium ( $MSC > MB$  at quantity  $Q_2$ ).

Similarly, with a positive externality there is underproduction as the marginal social benefit exceed the

marginal cost at the market equilibrium. In this instance marginal social benefit is equal to the marginal private benefit plus the marginal external benefit ( $MSB = MPB + MEB$ ).

## Shadow Prices and Externalities

As externalities are a prevalent issue in CBA it is crucial that the appropriate shadow price is used in the analysis to ensure the net social benefit reflects the project accurately. Usually, the shadow price is captured as an external benefit or cost component in the CBA rather than a change in the market price used in the evaluation of the project i.e., we may calculate the marginal external cost or benefit directly. However, if we can observe the marginal external cost directly in the market, we can use the shadow price that reflects the true value of the good or service. Specifically:

- For a negative externality, the shadow price that should be used is the price that captures the true value of the good or service. In this instance it would be the point where  $MSC = MB$  at the point of allocative efficiency (price  $P_2$  in Figure 8.9).
- For a positive externality, the shadow price that should be used is the price that captures the true value of the good or service. In this instance it would be the point where  $MC = MSB$  at the point of allocative efficiency.

Questions can arise on whether we can exactly determine the amount of the marginal external cost to be used as a shadow price. When an externality is more complex, it is possible to consider non-market valuation methods as outlined in [Chapter 12](#).



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### Case Study Example: Bee Keeping

Bee keeping is a positive externality. Beekeepers raise colonies of bees to harvest their honey and sell it to the public. However, bees are crucial in plant pollination processes. By keeping and harvesting honey, the beekeepers have spill over benefits to those who grow fruits, vegetables, and flowers for a living. Without these bees, farmers would have to manually pollinate their crops. Consequently, by encouraging bee farming improves agricultural and horticultural crops.

In 2021, Business Queensland estimated that harvesting honey contributes a total of \$129 million to the Australian economy each year (Queensland Government, 2021). However, governments around the world have been aware of the progressive disappearance of bees and are attempting to implement policies to educate and support those who wish keep bees and correct the market failure.



Figure 8.10: "New Bee Keeper" by OakleyOriginals is marked with CC BY 2.0.

## (7) Corrective Taxes and Subsidies

Governments often levy taxes to resolve negative externalities and provide subsidies to resolve positive externalities. In these cases, we can consider the impact on the price used in the cost-benefit analysis. In the instance where the government intervenes in the market to correct an externality, we consider it a corrective tax or subsidy. A corrective tax is also known as a Pigouvian tax, implemented to correct the market failure, discouraging the activity as under a negative externality. Due to the negative externality, production is too high – exceeding what the socially optimum outcome would be. A Pigouvian tax is a targeted corrective tax implemented to increase the cost of production and encouraging producers to provide less output to the market. This type of corrective tax exists to “internalise” the externality such that marginal social benefit is equal to marginal social cost ( $MSB = MSC$ ). If a corrective tax is set at the efficient level, the amount of the tax would be equal to the marginal external cost ( $t = MEC$ ).

Some common examples of corrective taxes include alcohol, fuel, and tobacco. Corrective taxes are considered welfare improving as the tax directly corrects the consumption decision through higher prices, correcting the over consumption. In these examples, the taxes are being used to address clear externalities in

the form of incurred costs on other such as alcohol related violence, pollution, and healthcare respectively. In addition to this, corrective taxes generate benefits to the government in the form of revenues.

The same general rules hold for corrective taxes and subsidies. Explanations are provided below for your convenience.

### Corrective Tax in an Input Market (use $P_b$ ).

- If the corrective tax results in additional units of the input produced for use, that is from additional supply, use  $P_b$  – as this is the gross cost of the use of the input which represents the opportunity cost of production. This means you are pricing at the marginal external cost plus the buyer WTP.
- If the corrective tax results in the input of the good to be diverted from their current use in the economy, use  $P_b$  – as it represents the WTP of the foregone benefit to the users of the input caused by the diverted use.

### Corrective Tax in an Output Market (use $P_s$ ).

- If a corrective tax increases the availability of the good on the market use  $P_s$  – which represents the net benefit per unit supplied after the external cost is accounted for. Specifically, the buyer is demanding the good in this market at price  $P_b$ , we then subtract the external cost, which is equivalent to the tax, leaving  $P_s$  as the appropriate price.
- If a corrective tax diverts consumption of the output for use by others, use  $P_s$  – as the total external cost does not change because the quantity consumed does not change as a result of the tax.

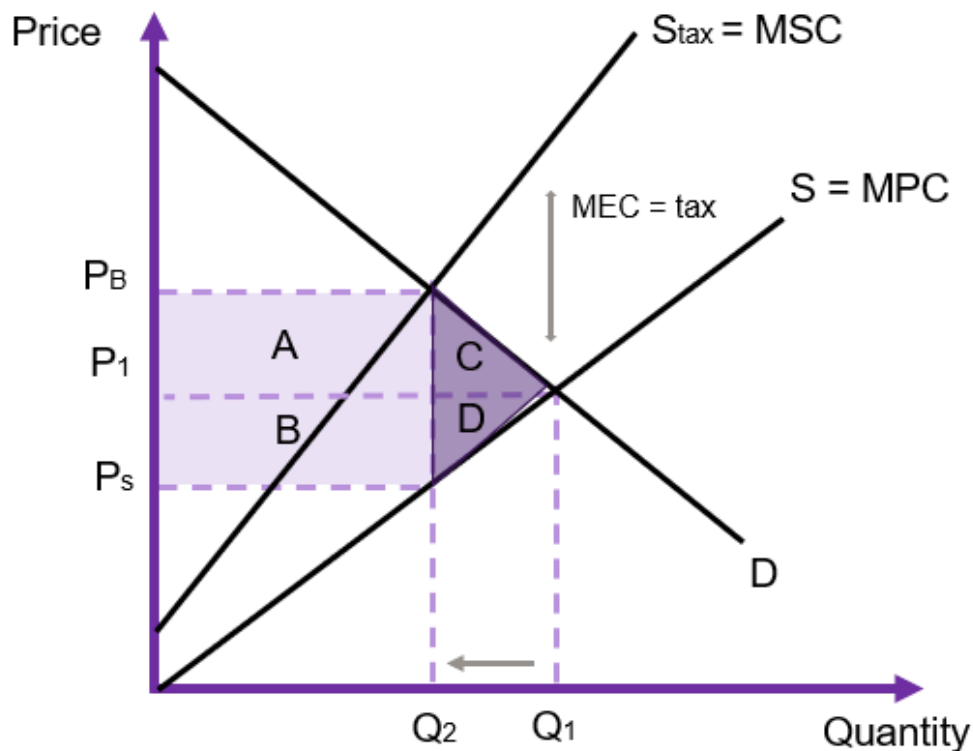


Figure 8.11: Impact of a Corrective Tax (Correcting a Negative Externality)

### Corrective Subsidy in an Input Market (use $P_s$ ).

- If the corrective subsidy results in additional units of the input produced for use, that is from additional supply, use  $P_s$  – as this is the gross cost of the use of the input which represents the opportunity cost of production. This means you are pricing at the marginal external benefit plus the sellers OC.
- If the corrective subsidy results in the input of the good to be diverted from their current use in the economy, use  $P_s$  – as it represents the opportunity cost of the foregone benefit to the producers of the input caused by the diverted use.

### Corrective Subsidy in an Output Market (use $P_b$ ).

- If a corrective subsidy increases the availability of the good on the market use  $P_b$  – which represents the net benefit per unit supplied after the external benefit is accounted for. Specifically, the buyer is demanding the good in this market at price  $P_s$ , we then subtract the external benefit, which is equivalent to the subsidy, leaving  $P_b$  as the appropriate price.
- If a corrective subsidy diverts consumption of the output for use by others, use  $P_b$  – as the total external benefit does not change because the quantity consumed does not change as a result of the subsidy.



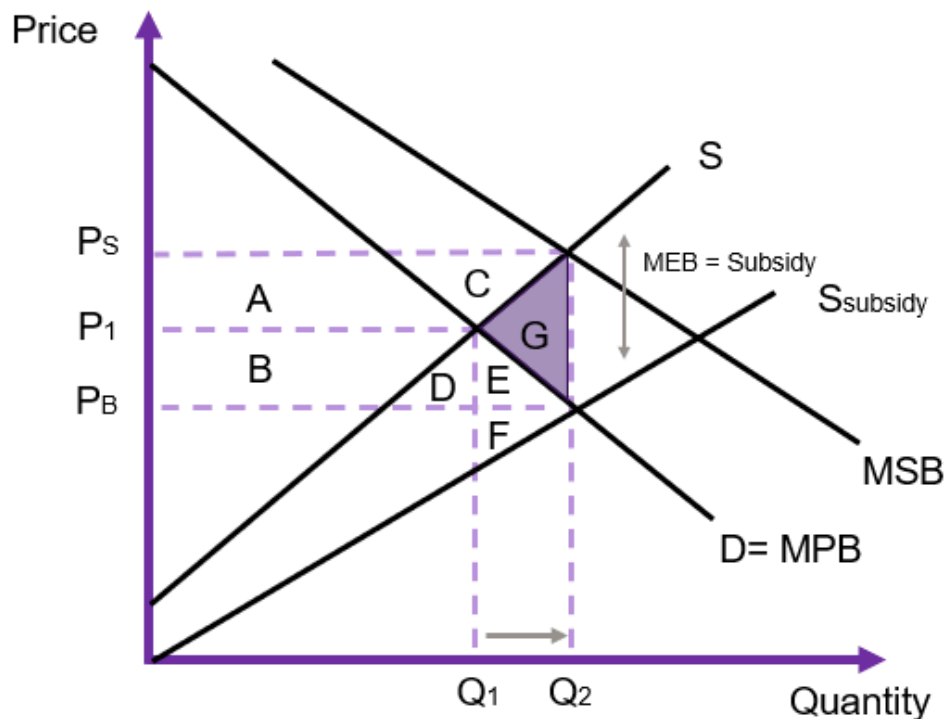


Figure 8.12: Impact of a Corrective Subsidy (Correcting a Positive Externality)

### Case Study: Corrective Taxes on Soft Drinks

Governments use taxes to correct negative externalities. The use of the tax is to internalise the external cost by increasing the cost and discouraging overconsumption. One of the most recent uses of corrective taxes relates to taxes on sugary drinks. Governments around the world have adopted such taxes to correct the health consequences from overconsumption of these drinks. Lal et al., (2017) estimated that an introduction of a 20% tax on these types of beverages would reduce healthcare costs by almost \$2 billion dollars through the prevention of dental health issues, diabetes, and heart disease. The collection of tax revenues governments can collect associated with these types of



Figure 8.13: "Soft Drinks MCP Project 52" by [carterse](#) is marked with [CC BY-SA 2.0](#).

interventions could subsequently be spent on healthcare interventions and other important public programs. From a CBA perspective, corrective taxes usually improve social welfare and should be undertaken.

## (8) Monopsony

We can think of a monopsony as a monopoly power in an input market. Explicitly, a monopsony occurs when there is only one buyer of a resource in an input market. Consequently, monopsonies are price setters in an input market. Monopsony power is likely to occur in labour markets, particularly when there is a small town where there is only one employer or for electricity generation markets. In this instance, as the buyer of the input the monopsony maximises their profit by restricting the amount of the factor of production the firm purchases. Therefore, the monopsony firm faces a marginal factor cost (MFC) curve which lies above the supply curve and is equal to the marginal expenditure (ME) on the input. The supply curve also represents the average cost of each unit of the input used. Additionally, there is no demand curve in a monopsony. Instead, the monopsonist faces a marginal revenue of product (MRP) curve (under the labour market example this is often referred to as the value of marginal product, VMP).

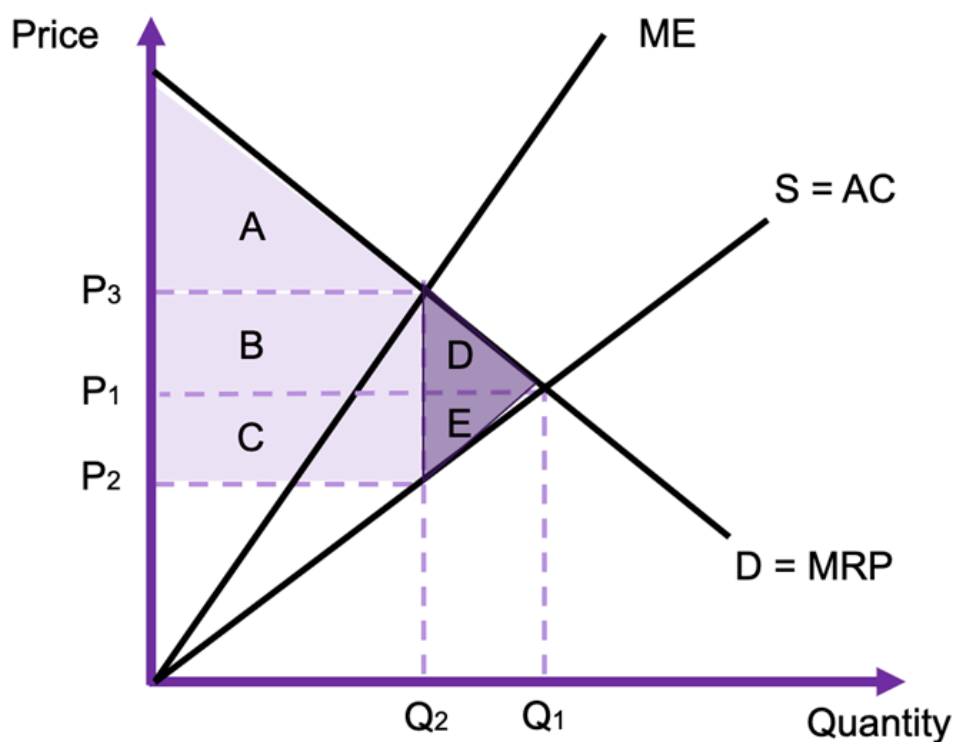


Figure 8.14:  
Market Distortion  
Caused by a  
Monopsonist

The monopsonist would purchase where the marginal revenue of product is equal to the marginal factor cost ( $MRP = MFC(ME)$ ). Consequently, the result in the market is a price below the competitive

equilibrium (price  $P_2$  in Figure 8.14). This creates a deadweight loss to society of the purple triangle D and E, and there is a transfer of rectangle C from the producers (e.g., the sellers of labour) to the monopsonist (e.g., the buyer of the labour).

From a cost-benefit analysis standpoint, we identify the following potential shadow prices for a monopsony:

- If intervention diverts the input from use by the monopsonist, the value to the monopsonist should be used as the shadow price. Specifically, the value of the resource to the monopsonist is  $P_3$  which is above the current market price  $P_1$  and price actually paid ( $P_2$ ).  $P_3$  is the value to the firm purchasing the labour input and represents the opportunity cost of the workers in the market.
- If the intervention increases the available resource for production, the opportunity cost represented by  $P_2$  should be used as the shadow price. This represents the price the monopsonist is willing to purchase the input.
- If the intervention only somewhat increases the availability of the resource, but not by the full amount, the shadow price should lie between the  $P_3$  price and the marginal cost (price  $P_2$ ).

## (9) Labour Market with Minimum Wage

One of the unique inputs for a policy or project that often experiences a distorted market is the labour market. When evaluating the appropriate price to use in the CBA we need to consider the labour input. An analyst must identify whether the policy or project decreases the available use of labour by others participating in the market or if the labour can be sourced from elsewhere (such as hiring unemployed workers). The results of the evaluation of distorted labour markets is subsequently easier to understand in comparison to the impacts of taxes and subsidies.

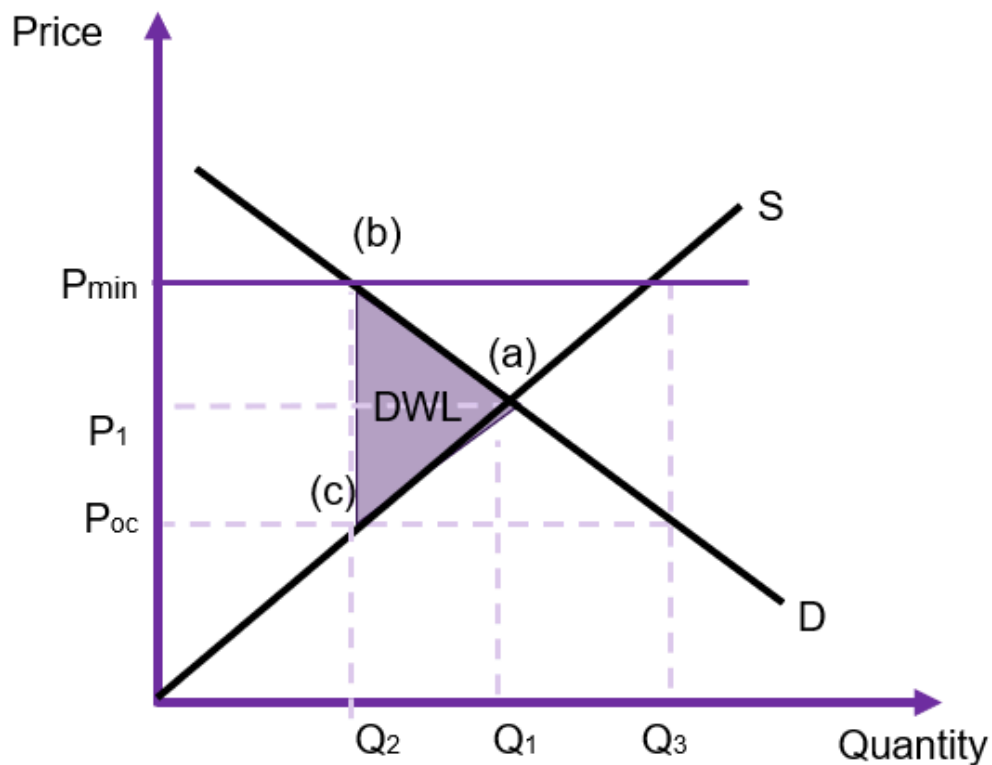


Figure 8.15:  
Market Distortion  
Caused by a  
Minimum Wage

- If the labour utilised is diverted from their existing uses elsewhere in the economy decreasing the availability, we should utilise the willingness-to-pay for that labour which is given by the price received by those workers already participating in the market. If we assume the market is affected by a minimum wage, this price would be at  $P_{min}$  in Figure 8.15.
- If the labour can be hired from unemployed workers, these workers should be priced at the opportunity cost of their labour which would be  $P_{oc}$  in Figure 8.15 as these workers would have otherwise not been employed.

It is important to note that sometimes we do not correctly account for the opportunity cost in some applications of CBA. For example, when governments value the time of jurors to provide compensation, often the full opportunity cost is not captured. Jurors receive the value of their market wage, and are compensated for travel and meals. However, there is no compensation for their lost time, leisure, and the absence from family. This is an area for potential improvements to be made in CBA to capture the true value of judicial proceedings.

## Conclusion

To round off the discussion of distorted markets it is important to note that there are other forms of market distortions including tariffs, quotas, price supports, etc., that can create difficulties in determining the appropriate shadow price to use to reflect the true value of the good or service on the market. We do not discuss these here but we provide the table below to assist in the process:

**Table 8.1: Summary of Shadow Prices Used in Distorted Markets**

Output	Input	Measure
Increases the availability to others (increases available consumption)	Decreases the availability to others (diverting from existing uses)	Willingness-to-pay
Decreases availability (diverting consumption by others)	Increases production (increasing availability for production)	Opportunity Cost

It is crucial to note that when calculating a social CBA, all values used should represent the true value of the costs or benefits. In this chapter, we identified the methods of adjusting the observed prices on distorted markets to capture the social value of inputs and output. We also discussed the marginal external benefit and marginal external cost associated with positive and negative externalities respectively. This is only part of the puzzle piece for conducting a social CBA as we still need to cover the context when a market does not exist for the item, good, or service being evaluated as part of the policy or program.

## Revision



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## Summary of Learning Objectives

1. We use the allocative efficiency of a competitive market as a benchmark for comparison. This allows us to identify potential Pareto improvements.
2. Shadow prices are required when the market price does not reflect the true value of the item, good, or service being evaluated as part of the CBA. We must use a shadow price to capture the true social benefit or social cost of an output or input. If we do not use a shadow price, we may overestimate or underestimate the net social benefit.
3. This chapter looked at how to shadow price across 9 potential market distortions including monopolies, distortive taxes and subsidies, information asymmetries, public goods, externalities, monopsony, minimum wages and corrective taxes and subsidies.
4. The selection of the appropriate shadow price depends on whether a tax is distortive or corrective.

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# CHAPTER 9: DISTRIBUTIONAL SOCIAL IMPACTS

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## Learning Objectives

**After completing this chapter, students should be able to:**

- 1. Identify stakeholders in the social CBA perspective.**
- 2. Describe the distribution of costs and benefits from the social CBA.**
- 3. Calculate the benefits and costs for those with standing in a CBA.**

There is an equity – efficiency trade-off when utilising cost-benefit analysis as a decision-making tool. In the previous chapter, we evaluated an intervention or project from the social perspective on the aggregate level. At this point, we need to disaggregate the benefits and costs to identify which groups the benefits and costs accrue to. This involves establishing those with standing in a policy or project as highlighted in [Chapter 4](#).

The goal of evaluating the distribution of benefits and costs is to provide information regarding the attractiveness of the project to stakeholders involved. Evaluating the distributional effects allows for the identification of equity issues in CBA (OECD, 2018). This allows for an analyst to determine the social desirability of a policy project or program. Additionally, when evaluating a policy or project based on the market prices, we fail to capture many aspects that are of interest to stakeholders. For example, we fail to capture benefits from employment, government surpluses from taxes and/or subsidies, and external impacts. When implementing the social CBA using the appropriate shadow prices, we capture these impacts indirectly. Disaggregating the effects involves attributing the benefits and costs to sub-groups within the CBA framework. For example, we can identify employment benefits to workers previously unemployed, taxes and subsidies would be received by governments, and external impacts can be attributed to the wider community or society.

At this stage, we assume equal weights to all relevant groups with standing where we measure dollar



for dollar the impact the CBA has on each relevant party. This is a limitation of our approach as it does not account for heterogeneity of groups within society. To address this issue, it is possible to re-weight the impacts across the distribution to account for inequality or diminishing marginal utility, to verify the desirability of a policy.<sup>1</sup>

## Identify Via Shadow Prices

The easiest method to evaluate and identify the benefits and costs attributable to various sub-groups involves looking at the use of shadow prices within the CBA. We know whenever there is a difference between the market price and the shadow price there must be a group that gains or loses. Specifically, we can evaluate the benefits and costs based on input and output markets as follows:

### For an input market:

- If the market price is greater than the shadow price, the benefit is to the owner of the input.
- If the market price is less than the shadow price, it is a cost to the user of the input.

### For an output market:

- If the market price is greater than the shadow price, it is a cost to the government or public.
- If the market price is less than the shadow price, it is a benefit to the government or public.

Therefore, when the shadow price is different from the market price, it is possible to identify the flow of the costs of benefits. Following from these general points outlined above, we can readily determine the benefits and costs that accrue to stakeholders with standing in the CBA.

It is important to pick up every instance of the differences between the market and shadow prices. The easiest way to implement this in a spreadsheet is to subtract the market prices from the social shadow prices. Any positive or negative difference implies a stakeholder with standing is affected and their gain or loss needs to be accounted for.

## Identify Via Financial Flows

A second method involves tracking the financial flows. There are two key types: (1) transfers to governments, and (2) lending institutions.

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1. Unweighted CBA can produce a decision that may reduce the social welfare, whereas if distributional weights are used the same policy may increase social welfare (Weisbach, 2015). However, the use of distributional weights is outside the realm of what is covered here.

## Transfers to and from the Government

This involves following the financial flows to and from the government in the form of taxes, subsidies, or other government expenditure. It is important to note that taxes and subsidies are transfers to the government. Taxes are an inflow (positive), and subsidies are an outflow (negative).

## Banks

Loans from banks or other institutional lenders are often captured in the disaggregated CBA. In some instances, we may exclude banks and lenders if the lender is a *foreign bank/firm*. This is due to jurisdictional considerations discussed in [Chapter 4](#).

## Aggregated and Disaggregated CBA

It is also worthwhile remembering that when you disaggregate the results of the social CBA, when you add impacts back together it should sum to the aggregate social CBA.

### Example 9.1

#### Example: Gains to Labour

Consider an infrastructure project which involves the purchase of labour for vegetation restoration. To complete the project, we require 10 workers. The market minimum wage for workers is \$25 per hour. Each worker is required for 7 hours for a total of 10 working days. If 60% of the workers hired for the project were otherwise unemployed, and their opportunity cost of working is 40% of the market wage, we can calculate cost of the project as follows:

- i) The market perspective =  $-\$17,500$  (wage  $\times$  workers  $\times$  hours  $\times$  days)
- ii) The investor perspective =  $-\$17,500$  (wage  $\times$  workers  $\times$  hours  $\times$  days)
- iii) The social perspective =  $-\$11,200$  (wage  $\times$  workers  $\times$  hours  $\times$  days  $\times$  employed + OC  $\times$  workers  $\times$  hours  $\times$  days  $\times$  unemployed)
- iv) The disaggregated social perspective = Investor perspective ( $-\$17,500$ ) + gains to labour ( $\$6,300$ ) = Social perspective ( $-\$11,200$ )

## Example 9.2

### Example: Taxes and Externalities

Suppose you have the following information about a single year project under consideration by a local FinTech firm. The information is as follows:

- Benefit = \$20,000
- Costs = \$15,500
- Taxes = \$3,000
- Pollution = \$2,250

We can identify the perspectives as follows:

- Market Perspective =  $\$20,000 - \$15,500 = \$4,500$  (benefits – costs)
- Investor Perspective =  $\$20,000 - \$15,500 - \$3,000 = \$1,500$  (benefits – costs – taxes)
- Social Perspective =  $\$20,000 - \$15,500 - \$2,250 = \$2,250$  (benefits – costs – pollution)
- Disaggregated to:
  - FinTech Firm = \$1,500
  - Government = +\$3,000
  - Community Costs = -\$2,250

The total of this disaggregated social CBA is equal to the social CBA perspective =  $(\$1,500 + \$3,000 - \$2,250) = \$2,250$

## Example 9.3

### Example: Producing Widgets

Suppose we have a project with the following information on the production of widgets over the life of a 5-year project.

**Table 9.1: Inputs for Widget Project**

Input	Value
Market Wage (per year)	\$6,000
Opportunity Cost per year (Workers Leisure)	50% market price
Workers Required Per Year	4
Initial Cost	\$1,500
Benefit (per unit/per year)	\$2,500
Units Produced Per Year	10
Discount Rate	5%
Tax Rate	25%

We can input the information into Excel to calculate the (i) market perspective, (ii) investor perspective, (iii) social perspective, and the (iv) disaggregated social perspective as follows:

**Table 9.2: The Results of the Four Perspectives of CBA**

	Year	0	1	2	3	4	5	NPV
(i) Market	Benefit		25000	25000	25000	25000	25000	
	Cost	-1500						
	Operating Cost		-24000	-24000	-24000	-24000	-24000	
	Net Private Benefit Before Tax	-1500	1000	1000	1000	1000	1000	
(ii) Investor	Tax		250	250	250	250	250	
	Net Private Benefit After Tax	-1500	750	750	750	750	750	\$1,747.11
(iii) Social	Benefit		25000	25000	25000	25000	25000	
	Cost	-1500						
	Operating Cost		-12000	-12000	-12000	-12000	-12000	
	Net Social Benefit	-1500	13000	13000	13000	13000	13000	\$54,783.20
(iv) Disaggregated								
	– Firm	-1500	750	750	750	750	750	\$1,747.11
	– Workers		12000	12000	12000	12000	12000	\$51,953.72
	– Government		250	250	250	250	250	\$1,082.37
	Consistency Check	0	0	0	0	0	0	\$54,783.20

To replicate this result you can download the Excel spreadsheet here: [Example9\\_3](#)

## Revision



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## Summary of Learning Objectives

1. By following financial flows and shadow prices we can identify the various stakeholders impacted by a policy or project.
2. We can disaggregate the result from the social CBA to identify who wins and who loses from a policy. When we aggregate the result from the disaggregation, we should attain the same result of the social CBA.
3. We can calculate the benefits and costs for the disaggregated CBA by looking at the differences between the market prices and shadow prices, along with financial flows (such as taxes, subsidies, and loan repayments to lenders).

### References

- OECD (2018), *Cost-Benefit Analysis and the Environment: Further Developments and Policy Use*, OECD Publishing, Paris, <https://doi.org/10.1787/9789264085169-en>.
- Weisbach, D. A. (2015). Distributionally Weighted Cost–Benefit Analysis: Welfare Economics Meets Organizational Design. *Journal of Legal Analysis*, 7(1), 151-182.

# CHAPTER 10: DEALING WITH UNCERTAINTY

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## Learning Objectives

After completing this chapter, students should be able to:

1. Identify and address uncertainty to estimate the net social benefit in a cost-benefit analysis.
2. Identify and evaluate risk in a cost-benefit analysis including expected value analysis.
3. Understand risk preferences in the context of cost-benefit analysis.
4. Implement sensitivity analysis in Microsoft Excel.
5. Effectively communicate the results of a sensitivity analysis.

## Dealing with Uncertainty and Sensitivity Analysis – How Big is a Piece of String?

Up until this point, we have assumed that all costs and benefits were known with certainty – however this is not a valid assumption. When conducting a cost-benefit analysis (CBA), an analyst often relies on estimates for variables that cannot be predicted with complete accuracy. Consequently, the result of the CBA is subject to risk and uncertainty, as the result cannot be determined with complete confidence. This chapter focuses on how a CBA analyst can evaluate risk and uncertainty involved in implementing a policy, program, or project to ensure the final recommendations provide clear decisions.

It is important to note that there is no exact method for dealing with uncertainty. However, it is important for an analyst to evaluate how risk and uncertainty may impact the result of the CBA. Despite this limitation, uncertainty must be evaluated in some form to determine if the results of the CBA are robust and consistent.

## Risk Versus Uncertainty

Risk is when the probability of the potential outcomes are known. When we can assign probabilities to all possible outcomes, and the set of possible outcomes is known the level of risk can be evaluated. Risk is often expressed as the expected outcome given the information available to the analyst. It is possible to quantify and evaluate risk using models. An example of risk would be placing a gamble on rolling a 1 when rolling a single die (1 in 6 chance) or when flipping a coin there is a 50 percent probability of “heads”. Under these circumstances, we can evaluate the risk as the outcome set is known along with the associated probabilities of each outcome.

Uncertainty is when the probability of outcomes is unknown or cannot be reasonably identified. We do not know all the possible outcomes and cannot assign probabilities to the outcomes. In addition to this, it is not possible for an analyst to control the level of uncertainty. An example of uncertainty is when we cannot predict when the next pandemic or epidemic. When the COVID-19 pandemic began, the likelihood of getting sick was unknown and the probability of dying was unknown – therefore it falls under uncertainty.

### Key Concept – Risk vs Uncertainty

Risk is where the probabilities of potential outcomes are known, while uncertainty involves unknown probabilities and unknown outcomes.

## Risk

Risk can be subjective or objective. Subjective risk is an individual’s perception of the likelihood of an event based on their opinion. Subjective risk can be different for each individual assessing and evaluating a situation or series of outcomes. Risk perceptions and heuristics can create bias in the evaluation of subjective risk such as optimism bias.<sup>1</sup>

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1. For example, an analyst suffering from optimism bias may overestimate the potential benefits of a project or underestimate the potential costs leading to the potential for an incorrect decision.



Objective risk involves deduction from previous occurrences of an event. Therefore, we can describe objective risk based on actual variations in outcomes. For example, there is a 50% chance when you toss a coin it is “heads” or a 1 in 6 chance that when you roll a dice you get a 3. It is possible to calculate objective risk by identifying the difference between the actual outcome and the expected outcome in an *ex-post* CBA.

Consequently, objective risk in CBA usually uses historical information whereas subjective risk in CBA relates to values assigned by the CBA analyst. Subjective risk differs from objective risk as the person identifying the risk or probability of an event has no way of identifying the actual likelihood of an event happening. In most cases, cost-benefit analysis involves some level of subjective judgement relating to the probabilities of potential outcomes. For example, cost-benefit analysis often relies on estimates of willingness-to-pay which captures subjective evaluations. Therefore, measures of willingness-to-pay are susceptible to subjective risk.

Distinguishing between the types of risk helps analysts better understand how risk will affect decision-making. It is well known that objective risk is observable and can be calculated using data and statistical information providing improved confidence in the results. However, in many instances in CBA the policies or projects may not be repeated and therefore the historical information may not be available for the evaluation of objective risk (i.e., there is no data available to assist the decision-making process).

Subjective risk has an element of psychological uncertainty as it is based on personal experience or perceptions. Additionally, subjective risk is known to alter the behaviour of people. For example, when people take out car insurance they engage in more risky driving behaviours (moral hazard). However, the use of subjective risk evaluation is to ensure consistency in decision-making across all information known to the analyst, taking a more holistic approach to the evaluation of risk.



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## Uncertainty

Uncertainty is a concern for all decision-makers. As part of the evaluation of a policy or program, uncertainties should be identified, and evaluated in a way that improves understanding of the policy or project under consideration. Values inputted into a cost-benefit analysis are forecasts of future impacts. Uncertainty arises from the possibility that the forecasts will be incorrect. Therefore, forecasts in cost-benefit analysis are tied to uncertainty. It is impossible for an analyst to identify all factors that may impact the net social benefit of a project under consideration. But, it is important to evaluate those uncertainties that matter most.

Uncertainty can be internal or external to the project (endogenous or exogenous respectively). When

uncertainty is internal to the project, there is an element of control over the input. Alternatively, external uncertainty comes from those factors beyond the control of the project. It is important to differentiate between the two types of uncertainty – those we can control and those we cannot – as the implications for the analysis differ. Consider a project for the development of a solar power station. The external uncertainty would relate to the market competition for electricity and internal uncertainty would be the price charged by the company for the electricity.

Furthermore, in CBA it is common practice to treat expected values as certain. Specifically, we have assumed constant year 0 pricing (real pricing) where the price does not change over time which required the use of the real discount rate. This involved inputting values used in the CBA as *point estimates* within the spreadsheet. However, it is likely that prices will change over time. Projects or policies with long durations will have uncertainty around the values. Consequently, an analyst should not pretend that the results are precise as their results represent only the best guess.

### Key Concept – Point Estimate.

A point estimate is a single value which is a “best guess” or “best estimate” of the value. So far in CBA, we have assumed the NPV result is certain and represents a point estimate of the project.

Additionally, an analyst cannot identify all factors that may impact the profitability of a policy or project, but it is important to identify the inputs which may change. Keep in mind that if the point estimates used in the CBA are inappropriate, then the resulting CBA is pointless. This comes down to the concept of “garbage in – garbage out”. The idea of garbage in – garbage out originated from computer science and information technology. The idea is that poorer quality information will result in poorer quality analysis of uncertainty. Although uncertainty does not mean that the input data is inaccurate, an analyst needs to be aware of this issue.

Overall, when evaluating risk and uncertainty in CBA it is important to evaluate: (1) what the degree of uncertainty is, (2) whether the uncertainty is a significant risk, and (3) whether the risk is acceptable. By doing this, we can ensure the processes used to evaluate the NPV of a project is robust as possible.



Figure 10.1: Inputting Bad Information Gives Bad Results – Garbage In = Garbage Out



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## Expected Value Analysis

Expected value analysis can be conducted if the possible set of outcomes can be defined. Expected value analysis involves modelling uncertainty as a set of contingencies with specified probabilities of occurrence. To model risk using expected value analysis, we need to know the set of possible outcomes (or potential “states of the world” in the future) and the probability of observing each of the possible outcomes.

This set of contingencies or events needs to be mutually exclusive and *collectively exhaustive*. Mutually exclusive implies that only one future state of the world can be observed. Collectively exhaustive means within the set of events, one of the events must occur in the future (i.e., one outcome of the set of potential outcomes is observed in the future). This directly relates to the rules of probability such that:

- (1) The probability of a random event ( $p_i$ ) lies between 0% and 100% chance for any event  $X_i$

$$0 \leq p_i(X_i) \leq 1$$

for all  $X_i$  and

- (2) the total sum of probabilities is equal to 1

$$\sum p_i(X_i) = 1$$

for all  $X_i$ .

To calculate the expected value, we multiply each possible outcome by the probability of observing that outcome:

$$E[X] = \sum X_i \cdot p_i(X_i)$$

where  $X_i$  is the event or outcome and  $p_i(X_i)$  is the probability of observing that event. These two probability conditions must be met to calculate the expected value.

If we know the set of possible “states of the world” we could face in the future, we can calculate the expected net present value (or expected net benefit) as follows:

$$(1) E[NPV] = \sum (p_i \times NPV_i)$$

where  $NPV_i$  is the NPV in state of the world  $i$  and  $p_i$  is the associated probability. Consequently, the expected NPV is the average of the possible outcomes from the project weighted by their probabilities. Hence, the expected NPV indicates the average outcome of the risky decision, if the decision were repeated a large number of times. If the expected NPV is positive, it suggests that the project should be undertaken. This is often referred to as the *expected NPV decision rule*.

Note that if a decision-maker has imperfect knowledge about the outcome of a project there is still a risk associated with that project – even if the expected NPV is positive. If potential NPVs are below zero, it is possible to experience a negative NPV after implementing the project. However, under the

NPV decision rule with certainty a project would be rejected if the NPV was negative. In expected value analysis, if one or more of the possible NPV outcomes is negative, it is crucial to consider further evaluation of potential outcomes using simulation such as Monte Carlo to reduce uncertainty and make a more informed decision.

Additionally, the expected NPV decision rule requires the decision-maker to be risk neutral. A decision-maker is considered risk neutral if the decision-maker is indifferent between an expected value of \$X and \$X with certainty. Treating expected values as if they are certain implies we are risk neutral – indifferent between certainty and the risky gamble outlined in the section below on [Risk Neutrality](#). In reality, decision-makers are not necessarily risk neutral. If the decision-maker is risk averse it would be inappropriate to use the expected NPV decision rule.

## Example 10.1

### Example – Calculating Expected NPV

Suppose there are three possible outcomes – a high NPV estimate of \$40,000, a best guess estimate at \$35,000 and a low NPV estimate of \$10,000. The associated probabilities of each possible outcome of the project are summarised in Table 10.1

**Table 10.1: Calculating the Expected NPV by Weighting Each NPV by the Probability**

Scenario	Probability	NPV (Xi)	Prob x NPV(Xi)
High	0.2	40,000	8,000
Best Guess	0.4	35,000	14,000
Low	0.4	10,000	4,000

$$E[NPV] = NPV_{high} \times \text{probability of } NPV_{high} + NPV_{best} \times \text{probability of } NPV_{best} + NPV_{low} \times \text{probability of } NPV_{low}$$

$$E[NPV] = 0.2 \times 40,000 + 0.4 \times 35,000 + 0.4 \times 10,000$$

$$E[NPV] = \$8,000 + \$14,000 + \$4,000$$

$$E[NPV] = \$26,000$$

To calculate this example in Excel you can download the spreadsheet here: [Example 10\\_1](#)



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You can download the spreadsheet for the above H5P question here: [Exercise 10\\_1](#)

One limitation of expected value analysis is the dispersion of potential outcomes is not captured. The expected value only provides information on the Expected NPV. It does not capture the dispersion of potential NPV outcomes. The dispersion (also known as the spread) of outcomes captures the risk of the project. Consequently, to measure the absolute measure of risk we calculate the standard deviation of the project.

To calculate the standard deviation, we need to calculate the variance. The formula for variance is:

$$(2) \quad \sigma_{NPV}^2 = \sum_{i=1}^n p_i \cdot (NPV_i - E[NPV])^2$$

Variance is a measure of risk – the higher the variance, the greater the risks associated with the probability distribution. However, standard deviation is the preferred metric of risk. This is because variance is measured in squared units. The standard deviation removes this aspect. Taking the square root of the variance gives the standard deviation i.e.,  $\sigma[NPV] = \sqrt{\sigma^2[NPV]}$ . The higher the standard deviation the greater the risk. The standard deviation provides information in the spread of NPV outcomes relative to the expected value. The larger the standard deviation, the more risk is involved in the project. Similarly, the smaller the standard deviation the lower the risk.

## Example 10.2

### Example – Calculating Variance and Standard Deviation of NPV

Consider the information from [Example 10.1](#), replicated in the table below:

**Table 10.2: Probability Distribution of NPV Outcomes**

Scenario	Probability	NPV (Xi)	NPV(Xi) – E(NPV)
High	0.2	40,000	14,000
Best Guess	0.4	35,000	9,000
Low	0.4	10,000	-16,000
Expected Value			26,000

From this example we can see the favourable outcome (high) has a probability of 20%, the best guess outcome has a probability of 40% and the unfavourable outcome (low) has a probability of 40%. These probabilities indicate that there is a high likelihood of an outcome of \$35,000 or below (an 80% chance).

Using Table 10.3, we can understand how to effectively apply the variance formula. First, we calculate the expected NPV (column 2) by taking the sum of probability weighted outcomes. Then we take the difference between each potential NPV outcome and the expected NPV (column 3). The difference is then squared (column 4). Finally, each of the squared differences is multiplied by the associated probability (column 4 multiplied by column 1). This result is then summed for the variance.

**Table 10.3: Calculating the Variance of the NPV**

Scenario	Probability	NPV ( $X_i$ )	NPV( $X_i$ ) – E(NPV)	$[NPV(X_i) –$ $E(NPV)]^2$	$[NPV(X_i) –$ $E(NPV)]^2 \times Prob$
	(1)	(2)	(3)	(4)	(5)
High	0.2	40,000	14,000	196,000,000	39,200,000
Best Guess	0.4	35,000	9,000	81,000,000	32,400,000
Low	0.4	10,000	-16,000	256,000,000	102,400,000
	Expected Value	\$26,000		Variance	174,000,000
				Standard Deviation	\$13,190.91

To subsequently find the standard deviation which represents the risk in outcomes, we take the square root of the variance i.e.,  $\sigma = \sqrt{\sigma^2} = \sqrt{(174,000,000)} = 13,190.91$ . To calculate it using the formula by hand:

$$\begin{aligned}
 \sigma_{NPV}^2 &= \sum_{i=1}^n p_i \cdot (NPV_i - E[NPV])^2 \\
 &= 0.2 \times (40,000 - 26,000)^2 + 0.4 \times (35,000 - 26,000)^2 \\
 &\quad + 0.4 \times (10,000 - 26,000)^2 \\
 &= 174,000,000
 \end{aligned}$$

To replicate this example you can download the spreadsheet here: [Example10\\_2](#)

Standard deviation is usually used to measure risk instead of variance as the interpretation of standard deviation is more intuitive with respect to the unit of measure. Variance for the NPV of a project will be measured in squared dollars (\$<sup>2</sup>), whereas standard deviation is measured in dollars (\$).

## Discrete vs Continuous Probability

There are many ways we can model risk in a cost-benefit analysis. Rather than using a point estimate (a single value) for an input in a CBA, it is possible to utilise discrete or continuous probability distributions to account for risk. The examples above use discrete probability to evaluate the risk associated with a policy or project. By modelling on a set of potential possible input values, uncertainty can be reduced. Computer programs such as the @risk add-in for Excel can be used when inputs are subject to continuous probability distributions.



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## Types of Uncertainty in CBA

We can categorise uncertainty into two types in CBA:

- 1) Uncertainty faced by economic agents – reflected in the approximation of willingness-to-pay and social surpluses (consumer and producer surpluses).

2) Uncertainty faced by the CBA analyst or policymaker – relating to the selection of inputs into the framework for analysis.

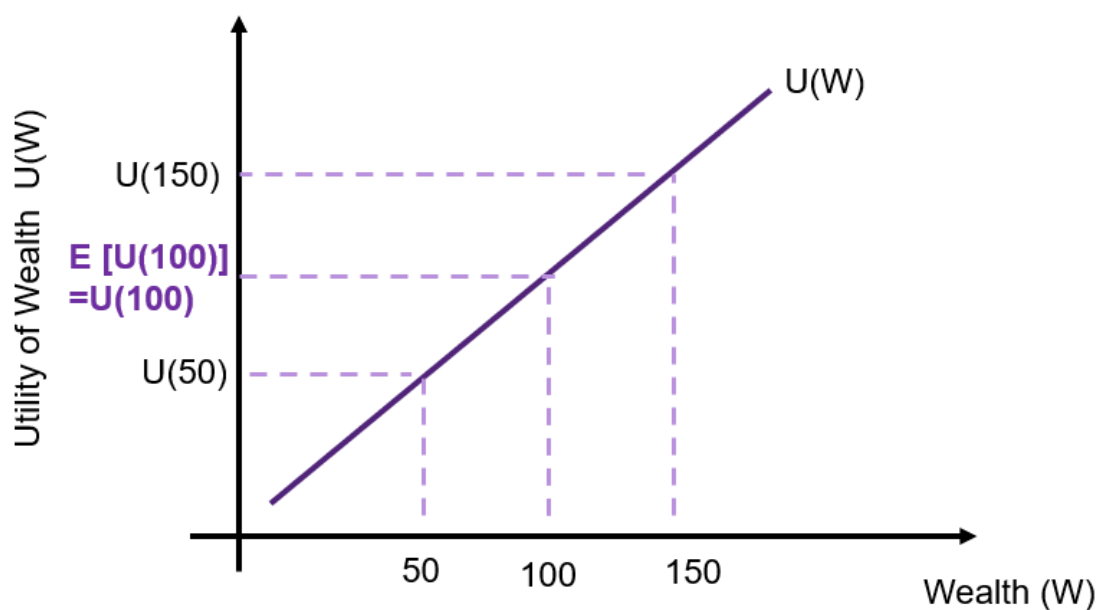
## Uncertainty Faced by Economic Agents – Risk Aversion

In economics and finance, attitudes to risk matter. We can categorise economic agent or individual into one of three possible categories: Risk averse, risk neutral, and risk loving.

Suppose we consider comparing \$100,000 with certainty against a gamble – the gamble has a 50% chance of giving 50,000 and 50% chance of \$150,000. The expected value of the gamble is \$100,000.

### Risk Neutral

A risk neutral individual is indifferent between a risky gamble and the payoff with certainty. This is illustrated in Figure 10.2 where the x-axis represents an individual's wealth, and the y-axis represents the utility derived from the wealth received. There is a linear relationship between wealth and utility. The utility is equal between the \$100,000 with certainty and the risky gamble with the expected payoff of \$100,000 i.e.,  $E[U(100)] = U(100)$ .



### Risk Averse

A risk averse individual has diminishing marginal utility (increasing utility at a decreasing rate) as shown in Figure 10.3. Again, consider the risky gamble relative to the \$100,000 with certainty.

The black dashed line represents the utility from the gamble – given as the tangent between the \$50,000 and the \$150,000. In this instance, a risk averse individual prefers \$100,000 with certainty over the gamble.



The utility from the certain \$100,000 is  $U(100)$  and it is above the expected utility received from the risky gamble  $E[U(W1)]$ .  $E[U(W1)]$  is known as the certainty equivalent. The difference between 100 and  $W1$  is the risk premium. The price the individual is willing to pay to ensure they receive  $W1$  with certainty in the gamble.

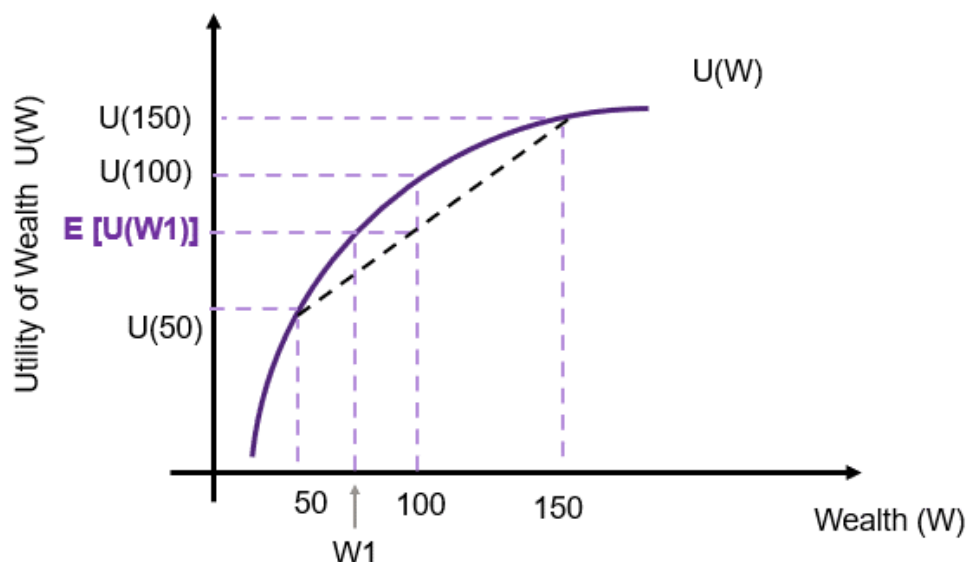


Figure 10.3: Utility and Wealth of a Risk Averse Individual

## Risk Seeking

A risk seeking individual has an increase marginal utility (increasing at an increasing rate) as shown in Figure 10.4. Again, the black dashed line represents the utility from the gamble – given as the tangent between the \$50,000 and the \$150,000. In this instance, the individual prefers the risky gamble to the certainty of \$100,000. This is shown through  $E[U(W1)] > U(100)$ . As a risk seeker, the individual would be willing to pay the difference between 100 and  $W1$  to take the risk.

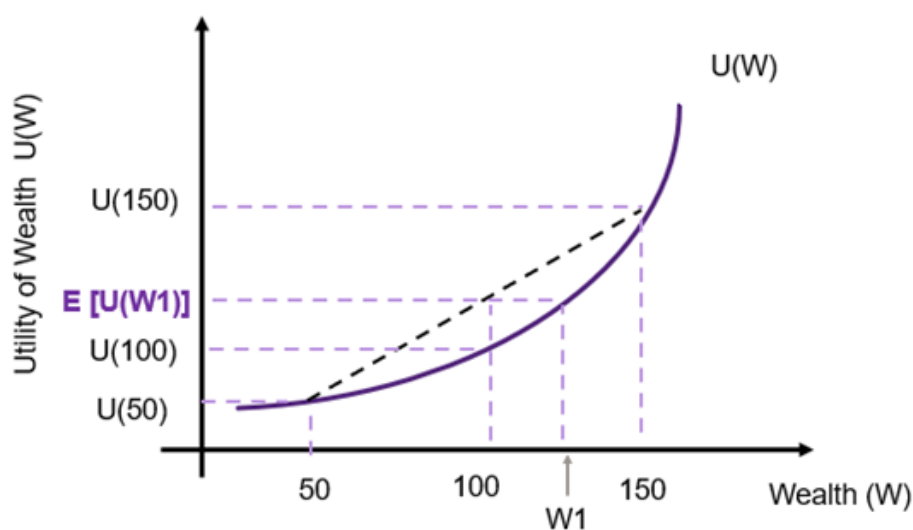


Figure 10.4: Utility and Wealth of a Risk Seeking Individual

By better understanding the risk profiles of individuals, we can account for risk aversion in our cost-benefit analysis. An example of the application of risk aversion to cost-benefit analysis can be found in [this paper by Kind, Wouter Botzen and Aerts \(2016\)](#).



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## Uncertainty Faced by the CBA Analyst or Policymaker

This type of uncertainty relates to the lack of information around the point estimates used in the CBA. To deal with uncertainty faced by the CBA analyst or policymaker, we implement sensitivity analysis outlined in the section below on [Sensitivity Analysis](#).

At this stage, it is important to note that when assessing a policy or project from the viewpoint of the government sector, an analyst often assumes a **risk neutral profile**. This is based on the aggregation of preference across stakeholders. However, it is possible to consider other risk profiles.

### Projects with Different Degrees of Risk

The expected net benefit or expected net present value does not highlight which project to select based on individual risk preferences. Choice of projects depends on a decision-maker's attitude to risk.

If we consider two projects (A and B) with different standard deviations as illustrated in Figure [10.5](#). As can be seen, if we evaluate the decision purely on the NPV, project B would be selected as  $NPV(B) > NPV(A)$ . However, evaluating the decision purely based on the NPV does not account for the fact that project B has a higher variation than project A i.e., project B is more dispersed and project A's NPV can be considered more certain. Consequently, the decision on whether the decision-maker is risk averse or a risk taker.

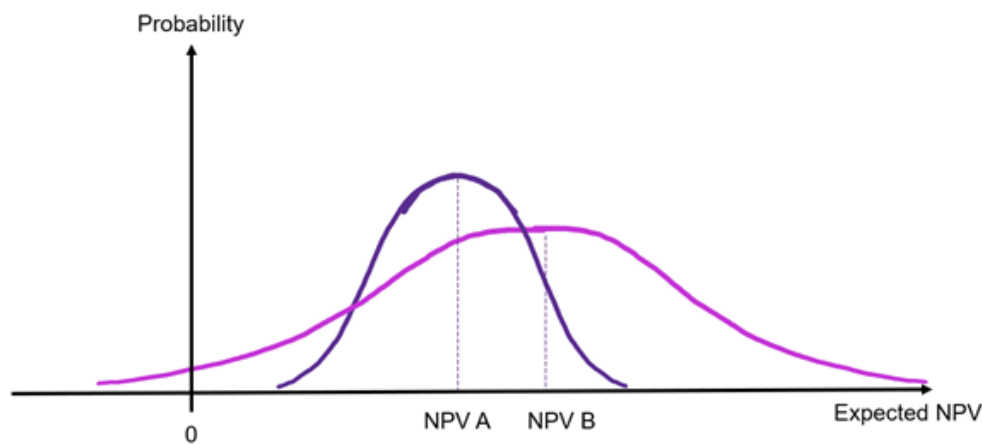


Figure 10.5: Two Projects with Different Degrees of Risk

To determine selection of projects based on risk preferences, we need to calculate the standard deviation. Using the information of both the risk and the expected NPV it is possible to evaluate the choice of project under different risk profiles. *A risk neutral investor will prefer the project with the highest expected NPV.* A risk seeker is willing to take on more risk (a higher standard deviation) for a greater reward, seeking a project with a higher risk if it provides a higher return. In this instance a risk seeker will likely take on a project with a higher level of risk if it is associated with a higher return. A risk averse individual would consider the trade-off between the expected NPV and the dispersion of possible NPV outcomes.<sup>2</sup>

## Sensitivity Analysis

Sensitivity analysis is a straightforward way to address uncertainty in cost-benefit analysis. Sensitivity analysis involves the evaluation of which outcomes are sensitive to the assumed inputs in the cost-benefit analysis. In this instance the outcomes we are evaluating are the net present value (NPV), internal rate of return (IRR), and the benefit-cost ratio (BCR). The purpose of a sensitivity analysis is to determine how much the net social benefit changes when assumed input values change. Sensitivity analysis is crucial as it identifies how independent inputs into the policy, program, or project can impact on the net present value – and therefore the potential profitability or desirability of the project.

Any cost-benefit analysis should be subject to a sensitivity analysis. Consequently, the sensitivity analysis is the last major step of the CBA before providing the recommendation or action.<sup>3</sup> Key components of the project should be subject to sensitivity analysis. If the net social benefit does not change significantly after the completion of a sensitivity analysis, the result of the CBA can be considered robust. Keep in mind that

2. It is possible to use the coefficient of variation to determine whether a project is worth the risk i.e., calculate  $CV = \frac{\sigma}{NPV_i} \times 100$ .

3. As mentioned in [Chapter A1](#), we specified “Perform a sensitivity analysis” as step 8 in the 9-step framework for conducting a CBA

evaluating potential outcomes under uncertainty is a subjective assessment and the selection of inputs for evaluation as part of the sensitivity analysis is also subjective.

The process of implementing a sensitivity analysis involves changing the underlying inputs that are key to the project to alternative potential assumptions to identify the impact of that variable (such as labour costs, initial capital costs, cost of resources, tax rates, et cetera.). This can involve changes in input prices or input quantities. There are four key reasons for conducting a sensitivity analysis:

- 1) Improves the robustness of the CBA results.
- 2) Allows for better understanding of the project and communication of results.
- 3) Reduce uncertainties through identification of inputs that cause significant fluctuations in the outcomes of interest. i.e., which factors will significantly affect the NPV of a project.
- 4) Provides an opportunity assess and effectively understand risks associated with a policy, project, or program.

We cannot use sensitivity analysis to predict the likelihood of an outcome, but we can check the extent to which the outcome is robust to a change in an estimated input used as part of the prediction and monetisation process. If the impact of a change in an input subject to sensitivity analysis is sufficiently large in percentage terms, the robustness of the CBA can be called into question.

## Sensitivity Analysis and the Discount Rate

The discount rate must always be subject to a sensitivity analysis. Specifically, in the implementation of policies or projects, the forecasts used will be sensitive to a change in the discount rate. In most instances, government departments have a range of discount rates that must be used in a CBA. However, in some instances it may be difficult to determine the appropriate discount rate. For example, the choice of discount rate for climate change mitigation is subject to much discussion and there is no set discount rate choice.

An analyst must evaluate the impact of the discount rate on the NPV of a project for several reasons:

- There is a clear inverse relationship between the NPV and the discount rate – as the discount rate increases, the NPV decreases. This was observed when we plotted NPV curves in the past.
- Selecting the wrong discount rate can potentially change the decision to accept or reject a project.
- When a project incurs large costs early and benefits later are more susceptible to changes in the discount rate. The choice of discount rate can make the NPV more susceptible to fluctuations.

Evaluating the choice of discount rate improves the robustness of the CBA. If the NPV is greater than zero under all discount rates considered as part of the sensitivity analysis, the results can be considered sufficient to support acceptance of the project. In the past we have implicitly completed a sensitivity analysis of the

discount rate by looking at how a change in the discount rate impacts the NPV.<sup>4</sup> It is possible to use any range for the sensitivity analysis on the discount rate.

We can also utilise the IRR to understand how sensitive a project is to the discount rate. As mentioned before, plotting the NPV curve identifies the IRR when the curve intersects the x-axis (Figure 2.6 from Chapter 2). This point is where the NPV is equal to zero, hence if the IRR is equal to the discount rate, the project's NPV would be zero and a risk neutral decision-maker would be indifferent between accepting and rejecting the project. If the IRR is higher than the discount rate, then it provides an economic justification to undertake the project. It is important to note that a high IRR may suggest a project is less sensitive to changes in the project inputs.

### Example 10.3

A project has the following costs and benefits over the life of the project summarised in Table 10.4. The results for a sensitivity analysis using 3, 5, 7 and 9% as the discount rate for the project is shown at the bottom of the table. The NPVs were calculated using the =NPV() function covered in Chapters 2 and 3.

**Table 10.4: Discount Rate Sensitivity Analysis**

Year	0	1	2	3	4	5
<b>Initial Cost</b>	-\$4,500					
<b>Annual Benefit</b>		\$1,250	\$1,250	\$1,250	\$1,250	\$1,250
<b>Annual Cost</b>		-\$150	-\$150	-\$150	-\$150	-\$150
<b>Net Benefit</b>	-\$4,500	\$1,100	\$1,100	\$1,100	\$1,100	\$1,100
<b>Sensitivity Analysis</b>						
<b>NPV @3%</b>	\$537.68					
<b>NPV @5%</b>	\$262.42					
<b>NPV@7%</b>	\$10.22					
<b>NPV @9%</b>	-\$221.38					

4. For example, in the worked example from the [Appendix](#), we used a 5%, 10% and 15% as discount rates in our estimation of the net present value.

The results of the sensitivity analysis can easily be summarised in a graphical illustration as shown in Figure 10.5 below. This is the NPV curve, plotted using the selected range of discount rates used in the sensitivity analysis.

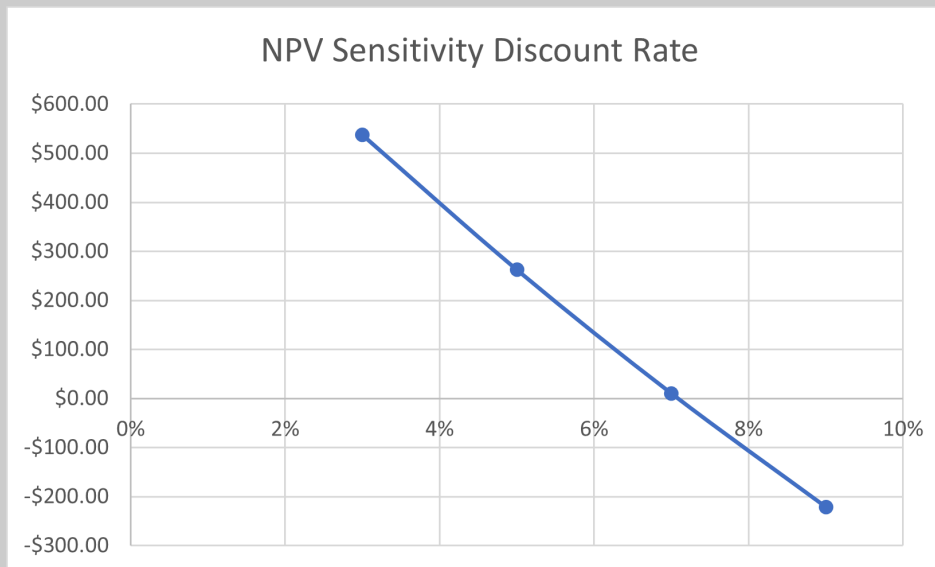


Figure 10.5:  
Sensitivity  
Analysis of the  
Discount Rate

To replicate this example, you can download the spreadsheet here: [Example10\\_3](#)

## Other Factors to Consider in a Sensitivity Analysis

A sensitivity analysis should be conducted on any project input that may be expected to have a significant impact on the outcome of the project (as measured by the NPV, IRR, or BCR). It is often suggested that an analyst considers conducting a sensitivity analysis in inputs such as:

- horizon/salvage values
- wages
- the value of statistical life
- environmental impacts
- growth rates
- revenues (including price and quantity produced)

This list is not exhaustive but provides a starting point for evaluating which inputs to consider when conducting the sensitivity analysis. One way of determining which cost or benefit inputs should be evaluated as part of the sensitivity analysis is by varying each input, holding all other inputs constant and

observing the change in the NPV.<sup>5</sup> Those factors that change the NPV significantly or change the sign of the NPV should be investigated further as part of the sensitivity analysis.

Additionally, when a point estimate is calculated as an input to the project (such as calculating a non-market shadow price), the confidence interval from the estimation process will provide an idea of how sensitive the project is to the point estimate element.

## Types of Sensitivity Analysis

We will look at three types of sensitivity analysis:

- 1) Partial sensitivity analysis
  - Single variable (One Factor)
  - Two Factor (using “What-if Analysis?” in Excel)
- 2) Best-worst case scenario analysis
- 3) Simulation (such as Monte Carlo)

The choices of which sensitivity analysis to utilise depends on the context of the project and the type of risk involved

## Partial Sensitivity Analysis

Partial sensitivity analysis is the most commonly used approach to assess the sensitivity of the NPV to a change in an assumed value for an input. A partial sensitivity analysis involves changing only one input or factor used in the CBA at a time. Example [10.3](#) above where only the discount rate was changed is an example of a partial sensitivity analysis.

To complete a partial sensitivity analysis in Excel, create a column or row of values you wish to consider. Then change the relevant cell to the values you have specified to compute the new NPV, BCR, or IRR. You can then record the results in Excel. This information can then be used to visualise the results of the partial sensitivity analysis.

---

5. Known as a partial sensitivity analysis.

## Example 10.4

### Example – Single Variable Sensitivity Analysis (One Way Partial Sensitivity)

Suppose a company is considering a project that will produce 100 widgets per year, over 5 years. The initial cost of the project is expected to be \$5,000. To produce the widgets there is a variable cost of \$2.00 per widget. Each widget is expected to be sold for \$15.00. The company tax rate is 25% and after the project is finished, the salvage value would be \$500. This information is summarised in Table 10.5.

Inputs:

**Table 10.5: A Company Producing Widgets**

<b>Initial Investment</b>	\$5,000.00
<b>Project Life</b>	5
<b>Salvage Value</b>	\$500.00
<b>Tax Rate</b>	25%
<b>Discount Rate</b>	5%
<b>Units Sold</b>	100
<b>Price Per Unit</b>	\$15.00
<b>Variable Cost Per Unit</b>	\$2.00

If the appropriate discount rate is 5%, it is possible to calculate the market perspective as shown in Table 10.6 below:

**Table 10.6: Market Perspective of Widget Production**

<b>Year</b>	<b>0</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>
<b>Benefit</b>		1500	1500	1500	1500	1500
<b>Initial Cost</b>	-5,000					
<b>Ongoing Cost</b>		-200	-200	-200	-200	-200
<b>Salvage Value</b>						500
<b>Net Benefit (Market)</b>	-5000	1300	1300	1300	1300	1800
<b>NPV Market</b>	\$1,020.08					
<b>IRR Market</b>	11.77%					



To conduct a partial sensitivity analysis, we change only one input – holding all other inputs constant. This involves changing only one cell to see how the NPV and the IRR change. For example, we can change the discount rate by 1% increments between the range of 3% to 7%. The NPV at 3% would be \$1,384.92, at 4% \$1,198.33 etc. It is possible to conduct a partial sensitivity analysis on many other inputs into this CBA. An example summary of a partial sensitivity analysis is provided below in Table 10.7.

**Table 10.7: Partial Sensitivity Analysis Using the Discount Rate**

<b>Partial Sensitivity Analysis</b>					
<b>Discount Rate</b>	<b>3%</b>	<b>4%</b>	<b>5%</b>	<b>6%</b>	<b>7%</b>
<b>NPV</b>	\$1,384.92	\$1,198.33	\$1,020.08	\$849.70	\$686.75
<b>Units Sold</b>	<b>80</b>	<b>90</b>	<b>100</b>	<b>110</b>	<b>120</b>
<b>NPV (@5%)</b>	-\$105.58	\$457.25	\$1,020.08	\$1,582.91	\$2,145.75
<b>Variable Cost Per Unit</b>	<b>1</b>	<b>1.5</b>	<b>2</b>	<b>2.5</b>	<b>3</b>
<b>NPV (@5%)</b>	\$1,453.03	\$1,236.56	\$1,020.08	\$803.61	\$587.14
<b>Salvage Value</b>	<b>320</b>	<b>400</b>	<b>500</b>	<b>600</b>	<b>720</b>
<b>NPV (@5%)</b>	\$879.05	\$941.73	\$1,020.08	\$1,098.44	\$1,192.46

See if you can replicate this table by downloading the spreadsheet here: [Example10\\_4](#)

After a partial sensitivity analysis has been conducted it is possible to identify the key variables that impact the NPV significantly. From this point it is possible to generate a table of results that allow for variations in combination for the inputs. This is illustrated in the two variable partial sensitivity analysis outlined in Example 10.5 below.

## Example 10.5

### Example – Two Variable Partial Sensitivity Analysis

Consider the company from Example 10.4 above. We have the following information on the best guess (point estimates) for the project summarised in Table 10.8.

**Table 10.8: Inputs of the Company Producing Widgets**

<b>Initial Investment</b>	\$5,000.00
<b>Project Life</b>	5
<b>Salvage Value</b>	\$500.00
<b>Tax Rate</b>	25%
<b>Discount Rate</b>	5%
<b>Units Sold</b>	100
<b>Price Per Unit</b>	\$15.00
<b>Variable Cost Per Unit</b>	\$2.00

We can use the “What If Analysis” function in Excel to conduct a two variable partial sensitivity analysis. Suppose the company is interested in conducting an analysis on the number of widgets sold varying by  $\pm 10\%$ , and the variable cost per unit, varying by  $\pm 25\%$ . To conduct an analysis of changes in these two inputs we need to create a matrix table as shown in Figure 10.6, where the Units Sold has been provided in the row and the variable cost per unit is in the column of the matrix.

		<b>Two Variable Sensitivity</b>			
		<b>Units Sold</b>			
		<b>\$1,020.08</b>	<b>90</b>	<b>100</b>	<b>110</b>
<b>Variable Cost Per Unit</b>	<b>1.50</b>				
	<b>2.00</b>				
	<b>2.50</b>				

Figure 10.6: Two Variable Sensitivity Analysis Matrix in Excel

The information in the top left references the output we wish to conduct the sensitivity analysis on – in this case the Net Present Value from our best guess estimate of the CBA. We must equate this cell to the output from the market analysis as shown in Figure 10.7 below.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1														
2		<b>Inputs</b>												
3		Initial Investment	\$5,000.00											
4		Project Life	5											
5		Salvage Value	\$500.00											
6		Tax Rate	25%											
7		Discount Rate	5%											
8		Units Sold	100											
9		Price Per Unit	\$15.00											
10		Variable Cost Per Unit	\$2.00											
11														
12		<b>Year</b>	<b>0</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>						
13		Benefit		1500	1500	1500	1500	1500						
14		Initial Cost	-5,000											
15		Ongoing Cost		-200	-200	-200	-200	-200						
16		Salvage Value						500						
17		Net Benefit (Market)	-5000	1300	1300	1300	1300	1800						
18		NPV Market	\$1,020.08											
19		IRR Market	11.77%											
20														

Two Variable Sensitivity			
Variable	Units Sold		
	90	100	110
Cost Per Unit	1.50		
	2.00		
	2.50		

Figure 10.7: Cell Referencing for Sensitivity Analysis (Cell K13 Referencing the NPV in Cell C18).

Once we have referenced the output cell for the sensitivity analysis, we have to highlight the matrix including the rows and columns as shown in Figure 10.8.

Two Variable Sensitivity				
Variable Cost Per Unit	Units Sold			
	\$1,020.08	90	100	110
	1.50			
	2.00			
	2.50			

Figure 10.8: Highlight the Matrix of Inputs Including Headings

Once highlighted – go to Data in the ribbon as shown in Figure 10.9.

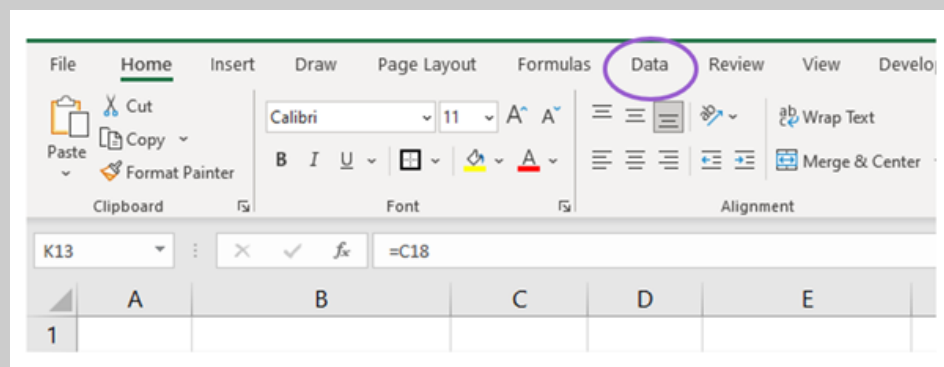


Figure 10.9: The Location of the Data Tab in the Excel Ribbons

Then go to “What-If Analysis” and click on “Data Table...” (shown in Figure 10.10)

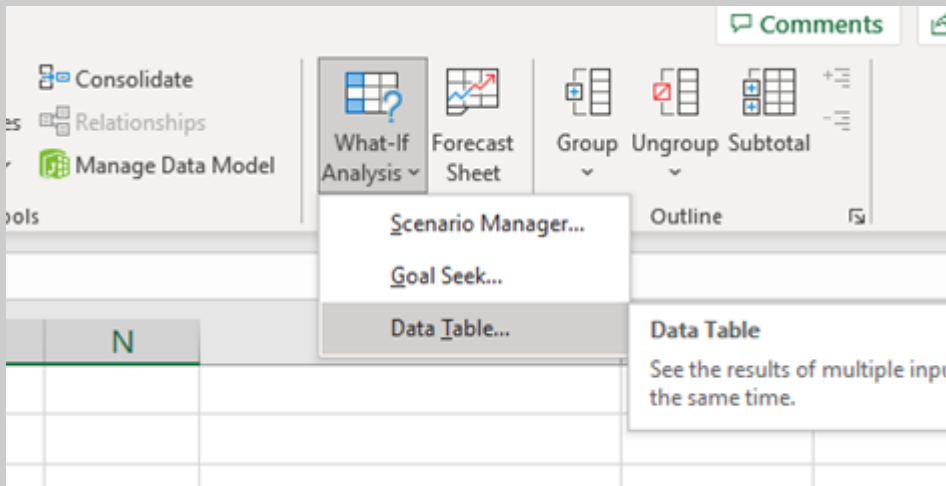


Figure 10.10:  
What-If Analysis  
and Data Table...  
Interface Selection

The row input in this case is the initial “Units Sold” cell and the column input is the “Variable Cost per Unit” cell. Under the “inputs” section of the spreadsheet as shown below in Figures 10.11 and 10.12.

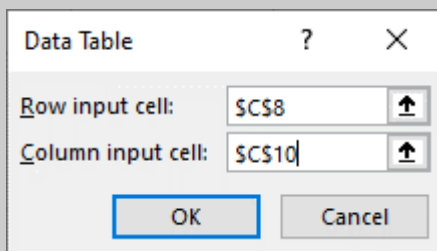


Figure 10.11: Inputs  
for the Pop-Up  
Window Including  
Row and Column  
Inputs

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1														
2			<b>Inputs</b>											
3			Initial Investment	\$5,000.00										
4			Project Life	5										
5			Salvage Value	\$500.00										
6			Tax Rate	25%										
7			Discount Rate	5%										
8			Units Sold	100										
9			Price Per Unit	\$15.00										
10			Variable Cost Per Unit	\$2.00										
11														
12			<b>Year</b>	<b>0</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>					
13			Benefit		1500	1500	1500	1500	1500					
14			Initial Cost	-5,000										
15			Ongoing Cost		-200	-200	-200	-200	-200					
16			Salvage Value						500					
17			Net Benefit (Market)	-5000	1300	1300	1300	1300	1800					
18			NPV Market	\$1,020.08										
19			IRR Market	11.77%										

Data Table
 

7

×

Row input cells: \$C\$8
 

▼

Column input cells: \$C\$10
 

▼

OK

Cancel

Two Variable Sensitivity				
		Units Sold		
		90	100	110
Variable Cost Per Unit	1.50			
	2.00			
	2.50			

Figure 10.12: Final  
Shot of Example  
Before Selecting  
OK.

Once you click “Ok” the matrix will fill with the results of the two-factor sensitivity analysis as shown in Table 10.9 below.

**Table 10.9: Two Variable Sensitivity Analysis**

Two Variable Sensitivity				
		Units Sold		
	\$1,020.08	90	100	110
Variable Cost Per Unit	\$1.50	\$652.08	\$1,236.56	\$1,821.04
	\$2.00	\$457.25	\$1,020.08	\$1,582.91
	\$ 2.50	\$262.42	\$803.61	\$1,344.79

See if you can replicate this table by downloading the spreadsheet here: [Example10\\_5](#)

## Best-Worst Case Scenario

Best-worst case analysis involves identification of various combinations of inputs to generate a pessimistic and an optimistic outcome. This is then evaluated relative to the best guess scenario. For example, often in infrastructure projects best-worst case sensitivity analysis involves varying key cost inputs by  $\pm 25\%$  of their original value.

There is no golden rule on how much variation around the best guess outcome is required. However, 20-25% is fairly standard for capital heavy projects such as infrastructure developments.

### Example 10.6

Consider the same company from Example 10.4 and 10.5 above. To implement the best-worst case sensitivity analysis an analyst needs to start with the point estimates (the best guess) and select the variation on either side of the key variable that is appropriate. Suppose from the information above we conduct a sensitivity analysis using the information in Table 10.10:

**Table 10.10: Selected Combination for Best-Worst Case Analysis**

Best Worst Case	Pessimistic	Best Guess	Optimistic
Units Sold	-20%	100	+20%
Price Per Unit	-20%	\$15.00	+20%
Variable Cost Per Unit	+25%	\$2.00	-25%
Initial Investment Cost	+10%	\$5,000.00	-10%

From this, to calculate the best-worst case results we need to calculate the relevant input values using the deviations in the costs and benefits. Note that for pessimistic outcomes decrease the values of benefits and increase the values for costs (and vice versa for optimistic estimates).

Calculating the appropriate inputs gives the results in Table 10.11 below.

**Table 10.11: Calculated Values Used in Best-Worst Case Analysis**

Best Worst Case	Pessimistic	Best Guess	Optimistic
Units Sold	80	100	120
Price Per Unit	\$12.00	\$15.00	\$18.00
Variable Cost Per Unit	\$2.50	\$2.00	\$1.50
Initial Investment Cost	\$5,500.00	\$5,000.00	\$4,500.00

From this point to find the NPV under each three scenarios, we input the values from the table above. i.e., to estimate the pessimistic outcome we change units sold to 80, the price per unit to \$12, the variable cost to \$2.50 and the initial investment cost to \$5,500. This will give the following NPV's and IRRs under the pessimistic, best guess and optimist scenarios.

**Table 10.12: NPV Results Under the Three Scenarios**

Best Worst Case	Pessimistic	Best Guess	Optimistic
NPV	-\$1,817.83	\$1,020.08	\$4,464.13
IRR	-7.16%	11.77%	35.08%

Note that the results for the best guess in Table 10.12 were the same initial results using the point estimates from the initial CBA (as shown in Examples 10.4 and 10.5).

See if you can replicate this table by downloading the spreadsheet here: [Example10\\_6](#)



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<https://uq.pressbooks.pub/socialcba/?p=466#h5p-194>

## Simulations

Simulation analysis can be used as part of the sensitivity analysis. Simulations allow an analyst to test many assumptions regarding the project at the same time. When using simulation methods, we create a distribution of net benefits for each key input based on some key assumptions about the probability distribution of the underlying inputs in the CBA. Simulation analysis allows the exploration of uncertainty through the application of statistical techniques. The outcome provides the analyst with a range of statistical probabilities associated with the final outcome. Simulation will also provide insights into not only the expected value of the NPV, but the dispersion (variation) of the expected value.

One of the most popular methods for simulation in CBA is Monte Carlo simulation. Monte Carlo simulation is a computer simulation process that uses repeated random sampling. For each uncertain input, the analyst specifies a probability distribution. These distributions are drawn from once for each input, for each computation. The underlying input distribution can follow a uniform probability distribution, a continuous probability distribution, a triangular probability distribution or a cumulative probability distribution. These values drawn from the input distributions are then used to calculate the NPV. Repeating the process of drawing from the input distributions allows an analyst to estimate a distribution for the net present value which will provide in information on the expected NPV and standard deviation (along with other descriptors of the project inputs and outcomes). The standard deviation of the project to get a better understanding of potential risk.

Overall, simulation provides a structured approach to incorporating uncertainty and risk into the evaluation of the policy, program, or project under consideration.



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## Threshold Analysis

The final aspect we consider in this chapter is threshold analysis. Threshold analysis is an extension of

sensitivity analysis used to identify a minimum or maximum value of an input within the cost-benefit analysis. Specifically, threshold analysis aims to identify a specific goal for a value under consideration to be achieved to overcome a threshold point. For example, a company may want to find a minimum NPV or a tax rate that would meet a hurdle IRR which can be determined by conducting a threshold analysis.

## Example 10.7

### Example – Threshold Analysis

Again, using the example from before summarised in Table 10.13 and Table 10.14 below:

**Table 10.13: Inputs of the Company Producing Widgets**

Inputs	
Initial Investment	\$5,000.00
Project Life	5
Salvage Value	\$500.00
Tax Rate	25%
Discount Rate	5.00%
Units Sold	100
Price Per Unit	\$15.00
Variable Cost Per Unit	\$2.00

**Table 10.14: Market Perspective for Widget Production**

Year	0	1	2	3	4	5
Benefit		\$1,500	\$1,500	\$1,500	\$1,500	\$1,500
Initial Cost	-\$5,000					
Ongoing Cost		-\$200	-\$200	-\$200	-\$200	-\$200
Salvage Value						\$500
Net Benefit (Market)	-\$5,000.00	\$1,300.00	\$1,300.00	\$1,300.00	\$1,300.00	\$1,800.00
NPV Market	\$1,020.08					
IRR Market	11.77%					

Currently, the best guess NPV is \$1,020.08 when the discount rate is 5%.



Suppose the company wishes to determine the discount rate that would achieve a minimum NPV of \$1,500. To complete the threshold analysis, go to the Data ribbon. Click on the “What-If Analysis”. This time click on “Goal Seek” as shown in Figure 10.13 below:

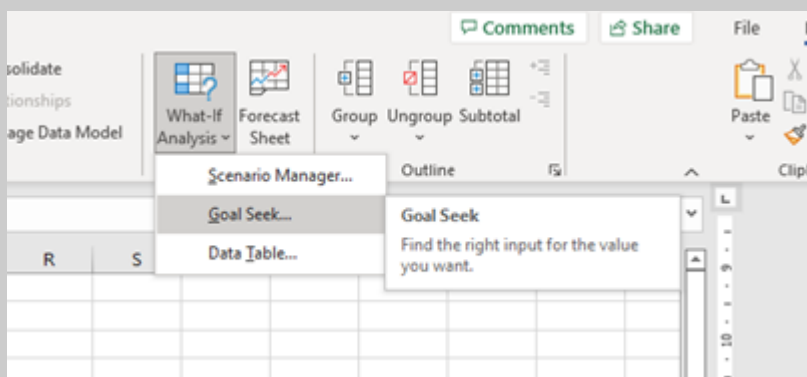


Figure 10.13:  
What-If Analysis  
and Goal Seek  
Interface Selection

You will see the following pop-up window:

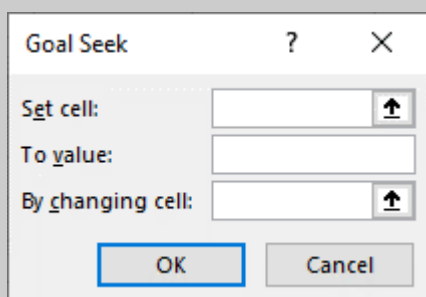


Figure 10.14:  
Pop-Up From  
Using Goal Seek  
Function

In “Set Cell”, select the cell you wish to change. In this case it would be the cell which contains the NPV of the project. In the “To value” box indicate the value you would like the input to take (in this instance \$1500). The “By changing cell” should reference the cell you want to change to achieve your minimum outcome, in this case you should select the discount rate. In this example the result of inputting this information is as shown in Figure 10.15.

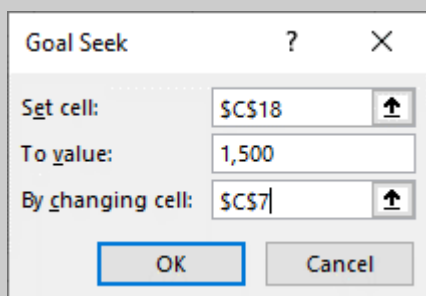


Figure 10.15:  
Inputting the  
Relevant Cells as  
Part of the  
Threshold  
Analysis.

After clicking “OK” the “By changing cell” will change to the threshold value. In this instance the discount rate is changed to 2.41%. This discount rate is the minimum discount rate that would achieve the requirement for the net present value to equal \$1,500. See if you can replicate this result by downloading the spreadsheet here: [Example10\\_7](#)



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<https://uq.pressbooks.pub/socialcba/?p=466#h5p-186>

## Communicating the Results

It is possible to deal with risk and uncertainty using expected value analysis and sensitivity analysis. It is important to convey the information in the sensitivity analysis clearly to the decision-maker. A good starting point is using tables and graphs. There are many graphs that can be used for a sensitivity analysis. It is common to include the NPV curve as it indicates the sensitivity to the discount rate. Bar charts, pie charts and line graphs may also be appropriate. When choosing a graph, consider what you would like to communicate to the reader of the CBA.

## Revision



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## Summary of Learning Objectives

1. When conducting a cost-benefit analysis, an analyst often relies on estimates for variables that cannot be predicted with complete accuracy. Consequently, the result of the CBA is subject to risk and uncertainty as the results cannot be determined with complete confidence. Therefore, an analyst must evaluate the risk and uncertainty associated with the evaluation of a policy or project.
2. An analyst can use expected value analysis to calculate the expected NPV and the standard deviation of a project.
3. We assume the decision-maker of a CBA is risk neutral. However, individuals who present their WTP may be risk averse, risk neutral or risk seeking.
4. By changing the cells in an Excel spreadsheet, it is possible to implement partial sensitivity analysis (one variable and two variable analysis). It is also possible to conduct a best-worst case scenario by varying the inputs by  $\pm 20\text{--}25\%$  to compare the results against the best case (point estimates). Excel can also be used to implement a simulation for sensitivity analysis.
5. The results of a sensitivity analysis can be communicated using tables and graphs.

# CHAPTER 11: ETHICAL AND SOCIAL ISSUES IN CBA

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## Learning Objectives

After completing this chapter, students should be able to:

1. Recognise the interaction between ethical concepts and social issues in economics.
2. Identify and apply the three ethical theories: utilitarianism, deontological, and virtue ethics.
3. Consider consequences of ethical decision-making in cost-benefit analysis.
4. Reflect on ethical decision-making.

## When Policy and Philosophy Collide

*“Logic clearly dictates that the needs of the many outweigh the needs of the few.” – Spock, The Wrath of Khan (1982)*

Up until this point we have treated every policy, program, or project as a black and white decision related to the calculated net present value – reject a project when the NPV is negative and accept the project when the NPV is positive. In reality, decision-makers would be fools to deal in absolutes.<sup>1</sup>

The foundations for cost-benefit analysis are underpinned by welfare economics. Welfare economics focusses on maximising the total social surplus. i.e., maximising the total benefit to society as a whole.

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1. Remember that only a Sith deals in absolutes!

When conducting a cost-benefit analysis, the process involves identifying the costs (negative impacts) and the benefits (positive impacts) to determine if policy, program, or project will provide gains to society. As mentioned before, this process of selecting the largest gain is done by selecting the project with the highest net present value (NPV) as it measures our net social benefit – assuming that all costs and benefits to society have been accounted for. By selecting the project with the largest NPV, we achieve allocative efficiency which is vital in the decision-making process when approaching economics from a traditional perspective.

However, measuring efficiency is challenging as highlighted in [Chapter 8](#). When conducting a CBA, an analyst only evaluates the results from a set of possible outcomes providing a point of comparison. This comparison allows for the identification of the best allocation of resources from the set of possible choices. When conducting an analysis from only a series of *known* possible options, we cannot identify *all* possible uses of the resources. Furthermore, while CBA provides a structured framework in which we can identify the best projects in a systematic way and has become an accepted tool for the evaluation of decisions, it does not provide context on the implications on fairness or equity in the decision-making process. Consequently, this chapter will cover the interaction between contemporary ethical and social issues and the role of cost-benefit analysis as a tool to support decision-making.

## Why Consider Social Issues in Decision-making?

Economic issues revolve around what goods and services to produce, how to produce, how to distribute goods and services, and whom you are producing for (the consumption of goods and services). This comes back to the idea of *scarcity* and how economic agents try to satisfy unlimited wants and needs with limited resources. Often secondary to economic issues is the application of economic principles to social issues.

Social issues are distinct from economic issues. Social issues are matters that directly or indirectly affect a person, groups of people or society. Social issues are considered problems related to **moral values**. Social issues focus on problems or concerns that undermine the wellbeing of society, usually with an emphasis on negative influences. Consequently, social issues can be subjective or objective.

### Key Concept – Morals

**Morals** or **Moral values** are standards of behaviour or principles of what is right or wrong.

Common examples of social issues in economics revolve around how public policy can be used to address environmental issues, distribution of wealth and income, poverty and inequality, gender differences, altruism, crime and corruption, gambling, homelessness, etc. These issues are complex in nature and cover many areas of economic studies. Contemporary social issues in economics are often related to “wicked problems” or “grand challenges” in economics – issues that do not have an easy solution.

The focus of social issues in cost-benefit analysis revolves around utilising *social* cost-benefit analysis to evaluate the choices made by firms and governments. Hence, the emphasis on *social evaluation* and the *integration of social impacts* into a CBA – beyond economic and financial appraisal methods previously dominating the literature.

Implicitly we have approached cost-benefit analysis from a social perspective from the introduction in this book to emphasise the use of CBA to evaluate and address social issues and social choices. The question then becomes – *why do we care about ethics in decision-making?*



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## Why Consider Ethics in Decision-Making?

Ethics is not often considered part of “doing” economics as it falls outside of the analytical style of developing and implementing models to communicate concepts and theories. Many areas of economics that undergraduate students have engaged with are likely to ignore or dismissed ethical overtones in their applications. However, all economic activities, policies, and decision-making processes have some form of ethical consequence in the form of value judgements. A value judgement is an assessment of an action or choice as good or bad in terms of one’s standards, objectives, or priorities. Consequently, economic policy implemented by governments can be influenced by value judgements. Therefore, we cannot exclude the role of ethics in learning economics if we want to achieve *social development*.

Additionally, there is a clear role of ethics in economics and policy analysis. As highlighted by Hausman and McPherson (2016), an understanding of moral philosophy and ethical theory helps individuals “do” economics.

### Key Concept – Ethics and Social Development

**Ethics** refers a defining set of principles that identify what is morally good and bad – what is right and what is wrong.

**Social development** – actions that are taken to improve the social, economic, cultural, and environmental conditions of society.

## Why Consider Ethics and Social Aspects in Cost-Benefit Analysis?

Society reflects the **ethics** and **morals** of the time. Rethinking of the ethical foundations of modern economics allows a shift in focus from “homo economicus” towards critical social issues including (but not limited to) climate change, financial crises, health crises, resource depletion, poverty, and food insecurity. The objective of discussing ethics is not to determine what is “right” and “wrong” but to sensitize and illuminate ethical questions. The goal of economic efficiency can often ignore fundamental **ethical norms**, including moral or immoral actions (such as climate change inaction or deliberately harming other people). By highlighting the interaction between economics and ethics, we improve the ability to make complex decisions, think critically and embark on our own personal development.

From a cost-benefit analysis perspective, consideration of ethical perspectives ensures that distributional impacts are appropriately identified and evaluated. Therefore, integrating ethics into the evaluation of cost-benefit analysis is necessary – even if only as reflective activity. This is challenging as there is significant diversity in ethics and morals. Specifically in CBA, it is important for us to consider all relevant stakeholders who may be impacted by a policy, program, or project. It is crucial that the implications of implementing a policy or program extends beyond monetary evaluation and considers different social, ethical, philosophical, and cultural backgrounds.



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## The Difference Between Ethics and Morals

Generally, the words ethics and morals are used synonymously implying there no difference between the concepts. However, for the purpose of this chapter, it important to understand the nuanced differences between ethics and morals. Making a simple distinction between the two concepts allows a better understanding of the interconnected nature of ethics and economics in both the cost-benefit analysis framework and decision-making in general.



### Key Concept – Ethics Versus Morals

Morals or Moral values are standards of behaviour or principles of what is right or wrong. Morals are dictated or framed by society or culture. There is an emphasis on shared social norms.

Ethics are rules of conduct or conventions that govern an individual's behaviour in deciding what is good or bad based on the moral beliefs or values in society. Ethics are chosen by a person or can be a standard identified by a community (such as Ethical Standards Boards). Ethics can therefore be considered a critical reflection on morals.

Unethical behaviour is behaviour that does not reflect the underlying the moral beliefs or values in society.

To highlight the difference, we can think of ethics in the purpose of economics as a “*What should I do?*” question, and morals are “*How it should work*”. Morals have both cultural and social aspects. Social norms, conventions, and cultural values will impact our morals. Whereas ethics are individual activities or beliefs in relation to the morals that we observe. Ethics is therefore an individual assessment of what is good or bad, while morality is a subjective community-based assessment of what is considered right or just in society. Consequently, we can think of ethics as a critical reflection on moral values.<sup>2</sup>

Morals are hard to define as there is a prominent level of culturally and socially acquired variation. What is “right” or “wrong” in one country may be perfectly acceptable in another country. For example, many countries around the world have implemented “Right to Die” or “Assisted Dying” policies allowing for voluntary euthanasia for individuals with terminal illness. However, in some countries it is considered morally wrong to implement such programs. Additionally, our personal ethics may not reflect the predominant moral view of society. Some people may be for or against voluntary euthanasia on a personal level.

When attempting to make moral decisions, we may have to sacrifice our own personal interests or personal ethics. Therefore, moral decision-making moves ethical decision-making into the social sphere. As can be seen, the two concepts are related, but the moral decision-making is more of encompassing of society as a whole, whereas ethical decision-making is individual level choices. An ethical action is one that is considered morally acceptable. Any ethical action must be considered morally acceptable for it to be ethical by definition.

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2. For additional discussion on the importance of ethics and morals in economics refer to this Conversation article: [Oh, the morality: why ethics matters in economics \(theconversation.com\)](https://theconversation.com/oh-the-morality-why-ethics-matters-in-economics)

Obviously, ethics and morals are very important in the context of decision-making in economics due to value judgements in our analysis and recommendations to policymakers.<sup>3</sup>



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### Case Study – Woolworths leaves pokies behind.

In 2019, Woolworths Group announced a “de-merger” from the Endeavour group. Through this process Woolworths Group plans to separate pokies, gambling, and liquor related revenue worth \$700 million per year from the corporation. Commentary on the issue highlights problematic gambling and reputational risks associated with this type of investment to Woolworths Group shareholders and a lack of cohesion with “Family Friendly Values.”

By separating Woolworths Group from the liquor and gambling markets, Woolworths is signalling that these investments are unethical and unaligned with the company’s ethical values – forgoing the earnings in favour of following their internal beliefs on what Woolworths Group should represent.

For additional information regarding the benefits and costs of this decision by Woolworths Group, consider reading this Conversation Article:

[Getting out of liquor, pokies will cost Woolworths, but deliver lasting benefits \(theconversation.com\)](https://theconversation.com/Getting-out-of-liquor-pokies-will-cost-Woolworths-but-deliver-lasting-benefits)



Figure 11.1: Pokie Machines. “[poker machines](#)” by [dennis](#) is licensed under [CC BY-NC-ND 2.0](#)

3. For further discussion see the section below on [Why Does Ethics Matter to Economics in General](#)

## What is an Ethical Dilemma?

An ethical dilemma exists when there is not a simple choice between what is right and wrong. When facing an ethical dilemma, it often leads to unpleasant choices. To solve ethical dilemmas, we need to apply complex judgements.<sup>4</sup> By understanding the role ethics takes in decision-making, we can identify and analyse conflicts associated with ethical dilemmas.

### Key Concept – Ethics and Economics

Reflection on economics and morality can potentially help many economists make better decisions, develop effective public policy, and assist in solving ethical or moral dilemmas.

## COVID-19 Lockdowns as an Ethical Dilemma

One of the ethical dilemmas at the forefront of contemporary discussion is lockdowns. Debate rages publicly on the trade-off between the economy and human life. By imposing lockdowns, infections can be managed and the spread of COVID-19 through the population can be controlled without significant hospitalisations and ICU intakes. This is important to ensure the healthcare system is not overwhelmed.

However, on the other side of the discussion is economic productivity. Lockdowns are known to negatively impact on short term economic growth, reduced social mobility, and the increased cost to mental health across the board ([Norheim et.al., 2021](#)). Additionally, increase inequity for socioeconomically disadvantaged or marginalised groups has push millions more people into extreme poverty ([World Bank, 2021](#)). This has exacerbated wealth inequality and inequality of opportunity – issues that have been at the forefront of discussion in economics for the past decade.

Consequently, lockdown policies can impact many social and economic factors. These factors need to be evaluated by decision-makers leading to many questions relating to ethical and political trade-offs. If you are interested in reading more about these issues, there are many resources online (peer reviewed and from alternative sources). Consider reading [this editorial by Whitehead, Taylor-Robinson and Barr \(2022\)](#) and this opinion piece by [Gak \(2020\)](#) as a starting point.

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4. Ethical dilemmas are sometimes also referred to as moral dilemmas.



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## Efficiency, Ethics, and the CBA Framework

As mentioned in [Chapter 1](#) and again in [Chapter 6](#), there is a clear link between cost-benefit analysis and welfare economics. Cost-benefit analysis is a tool for evaluating project, programs, and policies to ensure the selected use of limited resources is efficiently allocated. Our tool for evaluating the optimal allocation of resources is the net social benefit ( $NSB$ ), which is often measured by calculating the net present value when a project has an extended life. Assuming all social benefits and social costs are accounted for in the calculation of the net present value, analysts can identify the project that maximises the net social benefit. By accepting the projects that meet the decision rules outlined in [Chapter 2](#), scarce resources are allocated to their most valuable use. Therefore, cost-benefit analysis allows for the identification of efficiency. By operating as efficiently as possible, we should achieve pareto optimality.

Efficiency is a normative criterion for decision-making which can be derived from **utilitarianism**. Utilitarianism is an ethical theory that seeks “*the greatest good for the greatest number*”. In economics, this is equivalent to ensuring the maximisation of total social surplus. In cost-benefit analysis this is akin to selecting a project with the largest net social benefit. At its essence, utilitarianism involves maximising total utility of society without the consideration of the distribution of benefits and costs. A CBA analyst will undertake any policy or project that has a net benefit greater than zero as the benefits will exceed the costs. Therefore, cost-benefit analysis can be considered **operationalised utilitarianism**.



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## Social Critiques and the Kaldor Hick's Criterion.

Social critiques of cost-benefit analysis focus on the utilitarian assumptions. If the total social surplus is maximised, it is possible to trade utility gains and utility losses in a way that allows everyone to be made better off without anyone being made worse off. This is the key assumption of utilitarianism. Any cost-benefit analysis that identifies a policy or project as unequivocally beneficial (through a positive net social benefit) provides the government an opportunity to take actions or implement policies to ensure those

winners who receive positive payoffs can compensate losers who have negative payoffs the implementation of the policy or project. The compensation process would therefore meet the Kaldor-Hicks's criterion, which is a central feature of the utilitarian assumption.

However, for practical purposes we know governments seldom implement compensation in the real world. Hence, decision-makers are facing an equity – efficiency debate. To resolve these debates, understanding different ethical frameworks allow us to evaluate the relevant objectives of a policy or project to ensure effective decision-making.

### Key Concept – Normative versus Positive Economics

**Normative economics** involves analysing outcomes of economic behaviour to evaluate outcomes as good or bad. Normative economics is subjective in nature – “what ought to be”.

**Positive economics** is about understanding behaviours without making judgements about the outcomes. Positive economics is *objective* in nature – based on data and facts to describe “what is”.



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## Ethical Theories

Understanding ethical theories and their applications to economic and social issues provides guidance to evaluate moral dilemmas. An ethical point of view allows for better evaluation of decision-making through managing the context of decisions, resolving conflict, and dealing with uncertainty. Furthermore, by understanding some basic ethical theories, we can develop an awareness of the influence that values and behaviours may have on others.

For the purpose of evaluating decisions within a cost-benefit analysis framework, we will consider three ethical theories.

1. Utilitarian ethics
2. Deontological ethics
3. Virtue ethics

Note there are many ethical theories that can be applied into the context of decision-making. By studying whether actions are ethical we are applying *normative ethics* for practical purposes.<sup>5</sup>

## Utilitarian Ethics (Utilitarianism)

As mentioned previously, utilitarianism is the ethical theory that aligns with economic efficiency. Utilitarian ethics focuses on making decisions by identifying “*the greatest good for the greatest number*”, which directly aligns with the maximisation of total social surplus in the context of cost-benefit analysis. To better understand the link between utilitarianism and economics, we need to understand that utilitarianism is a form of consequentialism – the evaluation of a decision focuses on the *consequences* of the action or decision. To apply utilitarianism, a decision-maker determines whether the consequence or outcome of the decision is considered morally right or wrong on the basis of whether the action increases utility for society as a whole. In the case of CBA this is simply recognised by a positive net present value.

## Strengths of Utilitarianism as an Ethical Theory for Decision-making

- 1) It provides a **simple basis for formulating and testing policies** – by focusing on whether the outcome or consequence is considered right or wrong there are fewer issues for evaluating a decision. In a CBA framework it is very easy to identify the consequences of the policies or projects we are evaluating.
- 2) **Objective way of resolving self-conflict** – overall happiness or social utility is maximised under utilitarianism. This is an objective fact. Self-conflict is resolved by focus on society rather than the individual. This aspect also means there is no set of prior beliefs involved in the evaluation of the decision and the result is considered democratic.
- 3) It is **result orientated** – as utilitarianism is a form of consequentialism. An action or decision is considered right or wrong based only on the consequences without consideration of the character or motivation. Consequently, utilitarian ethics often dominates in applications and discussions of ethical decision-making.

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5. *Metaethics* is a different field where you study the nature of ethics.

## Criticisms of Utilitarianism

1) **The consequences of actions often go beyond the time frame for which the decision is made** – For example, we may consider a project that taxes alcoholic beverages. If we choose a time frame of 20 years to evaluate our tax policy, we may not capture the consequences outside of this time frame appropriately. Long term consequences are sometimes lacking in the analysis and decision processes.

2) **Utility measures are hard to effectively determine** – For instance, loss aversion, the endowment effect, reference dependence, framing, the desire for cognitive ease, status-quo bias, etc. may affect the outcome of a decision outside of the utilitarian framework. We would need to ensure the estimated gains and losses associated with a program are accounted for in a way that captures the asymmetry of the impacts.

3) **Often ignores minorities** – Under utilitarianism, the decision is driven on what is best for society. Distributional impacts of decisions are not accounted for. When implementing policies, we *should* consider any groups that may be disproportionately affected or subjected to unintended consequences. Essentially, in practice we would need to consider how to protect minorities and at-risk groups. Harming minority or at-risk groups is not good for the establishment of a positive reputation. Furthermore, the consequences of harms may be substantial. If these impacts are not accounted for the implications of the decision could be significantly damaging and result in irreversible effects. There is a fairly easy fix for this in a CBA framework, by looking at the distributional analysis outlined in [Chapter 9](#) to identify these issues.

4) We often ask the question “**should morality be tied to happiness?**” – While it is important to understand that people are always in pursuit of happiness and happiness is a worthwhile goal, there is heterogeneity in individual preferences along with heterogeneity regarding where each person derives their utility from.



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### Case Study: Fight Club – The Recall Coordinator’s Formula

This is a scene from the movie Fight Club (1999). You can watch a clip of this scene at the following external link to [Youtube](#) for better context of the excerpt below.

“A new car built by my company leaves somewhere traveling at 60 mph. The rear differential locks up. The car crashes and burns with everyone trapped inside. Now, should we initiate a recall? Take the number of vehicles in the field, A, multiply by the probable rate of failure, B, multiply by the average out-of-court settlement, C. A times B times C equals X. If X is less than the cost of a recall, we don’t do one.”

There is a clear ethical dilemma in this example. By applying the Recall Coordinator’s Formula, the assessor is applying utilitarian ethics. It leaves a clear question at the end – is this the appropriate action to take?

## Deontological Ethics

Deontology means the “study of duty” ([Larry & Moore, 2021](#)). Consequently, deontological ethics focuses on whether the action itself is considered right or wrong based on a series of rules or duties. The consequences of the actions are irrelevant to the decision, as the consequences are often difficult to foresee. The use of deontological ethics in decision-making relates to developing a sense of goodwill by following the universal moral norms or moral laws. In some instances, duties can be reflected in what the law states is right or wrong.

Deontologists often argue that we are unable to truly know the result of our actions and therefore we cannot determine whether it is right or wrong based on the *consequence*. Under deontological ethics, evaluation of the decision is based on *the action* in following *moral duties or rules*. Hence, we can think of deontological ethics as the opposite of utilitarian ethics.

The rules or duties that are applied to deontological ethics are often driven by universal moral laws. However, in some cases duties may also be tied to professional values or standards. These duties can be framed in a positive or negative format. Examples of duties include:

- Do not harm others
- Do not steal
- Do not cheat on examinations
- Follow the law
- You should keep a promise
- Respect your elders
- Avoid anti-social behaviours
- Protect people’s fundamental human rights



Deontological ethics does not require the evaluation of the costs and benefits of the action. Therefore, it is an alternative method for evaluating decision-making that does not fall into the cost-benefit analysis framework we have considered thus far.



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## Strengths of Deontological Ethics as an Ethical Theory for Decision-making

1) **Perpetuates the importance on every individual** – The approach is considered universal with a focus on fairness, consistency, and moral treatment of all people as equals. Consequently, it provides a basis for human rights. For example, one of the duties is to “not harm others”. Even when the consequences or result of harming someone is considered good, deontological ethics highlights that the action of hurting others is fundamentally wrong.

2) **There are natural moral laws or duties** – These natural moral duties are a clear set of rules for the decision-making process on whether the action is considered right or wrong. These duties are based on reason and are universally relevant regardless of race, religion, nationality, or gender.

3) **Duties are based on reason and not on subjectivity** – Unlike utilitarianism, costs and benefits for society are not evaluated and therefore there is no subjective assessment of what is right or wrong under deontological ethics if the rules or duties are followed.

## Criticism of Deontological Ethics

1) **Moral conflict may exist** – Under deontology, there is no clear way to resolve conflicting duties or moral conflicts. For example, when there is a duty to keep a promise conflicting with the duty to tell the truth or breaking a promise to ensure no harm is done to another individual. To demonstrate this further, suppose you were to attend a friend’s wedding and on the way to the venue you saw a pedestrian get hit by a car. If you stop to help the pedestrian in trouble you will break the promise to your friend but the action of helping someone in distress is considered itself “good”. Conflicts in duties often arise when circumstances change.

2) **Moral laws differ across society** – The existence of cultural relativism rejects the possibility that there are uniform standards or duties across cultures. Cultural relativism is the idea that cultures are fundamentally different from each other and therefore the moral frameworks and duties will be different between countries and societies.

3) Deontological ethics only works if **all people agree on the same duties** – Emphasising the role of the individual in determining if an action is moral or not.

4) **Duties change over time** – An extension of the previous limitation on social differences. Social norms and morals adapt from generation to generation resulting in the duties changing over time. For example, we can consider views and duties relating to climate change in the 1980-90's are still valid or should our duties reflect the new views of climate change now in the 2020's?

5) There is a possibility of **making the “right choice” that has bad consequences** – Again if the consequences are severe and may hurt or have unintended consequences on minorities or at-risk groups of society, we should consider whether evaluating the decision based only on the action appropriate. Therefore, it is possible to implement decisions that make society worse off under deontological decision-making.

6) **Underestimates the role of utility** in decision-making – The happiness of individuals and/or society is not considered.

From the description of deontological ethics, it is easy to see that the process is focused more on individual level decision-making based on what actions are considered appropriate, and utilitarianism is focused on social perspective of decision-making to maximise social benefits.

### Key Concept – Should You Keep a Promise?

Asking the question about keeping a promise allows for the evaluation of choices under **Deontological Ethics** compared to **Utilitarianism**. Deontologist would often argue that you should keep a promise made regardless of the consequences. However, utilitarians will argue that we should only keep promises if the result of keeping the promise is better than the consequences under the alternative situation. This is a clear actions versus consequences scenario.



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## Virtue Ethics

**Virtue ethics** is developed on the idea that we become good by practising good virtues rather than

following external rules. Actions that enhance good aspects of human interactions or decisions are considered good. Virtues are characteristics, motivations, attitudes or dispositions that are considered “good”. Specifically, a virtue can be thought of as a habit or character trait that shows ideals and is considered part of an individual’s identity, affecting their choices (Jonsson, 2011). Examples of virtues, generosity, honesty, compassion, self-control, etc. Unlike deontological ethics that focuses on moral duties, virtue ethics focuses on the *internal motivation of the decision-maker*. When applying virtue ethics to economics we are asking what makes a good person rather than what makes a good action or provides a good result in the decision-making process.



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## Strengths of Virtue Ethics as an Ethical Theory for Decision-making

- 1) **Virtue ethics is not bound by rules** – There is an element on flexibility as the focus is on being virtuous individual. When attempting to make decisions based on virtuous characteristics, there is better recognition of rational behaviour and social norms.
- 2) Involves a **personal aspect to the decision-making process** – Often framed as a “Should I do this?”, philosophical question. People over their lifetime develop and refine their virtues. Therefore, virtues in decision-making are linked to one’s ethical principles which can develop and refine over time.
- 3) There is an **emphasis on moral development** – Through moral development and moral education there can be changes and improvements to habits of people to improve and advance society. For example, changes to consumer choices related to the use of single use plastics and plastic waste started at an individual level with changes to personal behaviours (through recycling, reusable cups, reusable straws, etc.). These changes in morals have consequently led to many governments implementing bans on single use plastics.

## Criticism of Virtue Ethics:

- 1) **Does not provide a direction** for the problem or decision being evaluated – There is no clear guidance for moral dilemmas. Virtue ethics strictly looks at internal motivations of the person making the decision rather than the obligations to society.
- 2) There is **no general agreement regarding what good virtues are** – Like deontological ethics

where duties and rules can be hard to define, it is also difficult to define what good virtues are. There is heterogeneity driven by cultural and social norms.

3) **There are often conflicts of virtues** – For example, suppose you were to attend a friend's wedding and on the way to the venue you saw a pedestrian get hit by a car. The virtue of charity requires that you help someone in need (the pedestrian in distress), but at the same time the virtue of loyalty requires that you keep your promise to your friend. In either case, the decision-maker acts wrongly due to conflicting virtues.

4) **Can be often considered “situational ethics”** – Situational ethics is when the ethical decision-making is context dependent. Virtuous characteristics should be unchanged over time. However due to the potential for conflicting virtues like those mentioned in point 3 above, the result of the decision would change depending on the context.<sup>6</sup>



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### Key Concept – Visiting a Friend Who is Sick

Suppose you have a friend who has been sick for a few days with a non-contagious illness. If you visit your friend because it is your duty (deontological) or due to the expected consequences (utilitarian), it may be considered a moral flaw in your friendship as the visit is not conducted based on the “right” intentions. However, from the viewpoint of **virtue ethics**, being a good friend is considered virtuous characteristic. Therefore, by visiting your friend you are being morally good.



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6. Situational ethics is a whole different conversation for another time outside the scope of what is covered here.

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## The Three Ethical Theories in Economics and CBA

These three theories form the basis of normative ethics conversations. It is important to consider ethical and social aspects of decision-making to ensure all relevant stakeholders are accounted for and evaluated as part of the CBA. There is diversity in ethics and morals resulting in situation where the choices of government decision-makers may not reflect the norms of society. As CBA analysts, it is important to consider the ethical implications of policies, programs, and projects to ensure the final recommendations of the analysis are appropriate. The application of these three ethical theories also helps decision-making through managing context, conflict, and uncertainty that may arise.

### Case Study: Deontological Concerns Arise in Health Economics

Health economics is a specialised area of economics with its own challenge. One challenge that health economists are often affronted with is the ethics of using CBA to value human life.

To effectively conduct a cost-benefit analysis all costs and benefits must be expressed in a common measure, typically dollars, including things not normally bought and sold on markets. This includes improvements in quality of life, increased mortality (in years) and other health benefits – all of which require monetisation. To ensure that the social CBA reflects the true NPV these aspects should be captured a CBA analyst would ask “How do you value someone’s life?”.

When thinking of the ethics of valuing a life, a further question would be “**Should** you value someone’s life?”. Consequently, the area of health economics is growing and adapting to

create measures that do not create a moral dilemma such as Cost effectiveness analysis (CEA), and Quality Adjusted Life Years (QALYs).

## Examples of Ethical Applications – What is the Right Thing To Do?

Ethical understanding helps refine and manage decision-making, resolve conflict, and develop awareness of values and behaviours that influence our choices. To further refine our understanding of ethics, this section provides examples of ethical dilemmas and how various ethical theories can be used to explain the decisions made outside of the utilitarian approach in cost-benefit analysis.

### Example 11.1

#### The Trolley Problem

The trolley problem was first proposed by Philippa Foot in her paper [\*The problem of abortion and the doctrine of the double effect\* \(1967\)](#).

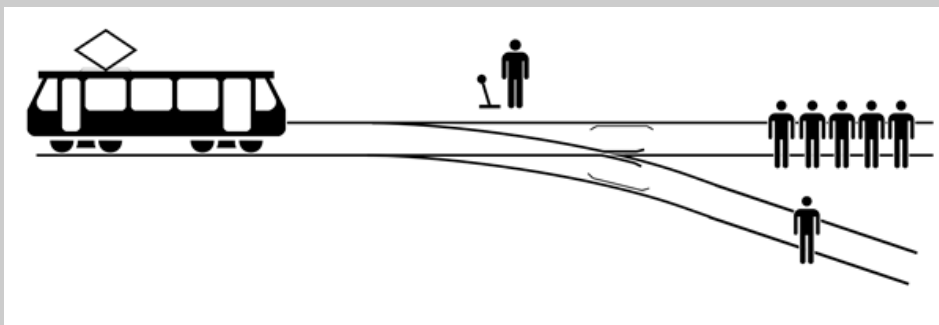


Figure 11.2: The Trolley Problem Illustrated. "Trolley Problem.svg" by McGeddon licensed under CC-BY-SA 4.0

The scenario:

*"The driver of a trolley has passed out at the wheel, and their trolley is hurtling out of control down the track. Straight ahead on the track are five people who will be killed if the trolley reaches them. You are a passer-by, who happens to be standing by the track next to a switch. If you throw the switch, you will turn the trolley onto a spur of track on the right, thereby saving*

*the five. But someone is on that spur of track on the right; and he/she will be killed if you turn the trolley.”*

### ***What do you do?***

In the context of the trolley problem, we are faced with the dilemma whether to throw (or flip) the switch. The choice made in this scenario will depend on the ethical approach of the individual making the decision.

#### **Utilitarian Approach.**

In this classic example, when applying utilitarianism you should flip the switch, because you save five people, and you lose one person. Thereby you are maximising the number of lives saved (or minimising the number of lives lost). From a CBA perspective this is the correct course of action as the benefits of flipping the switch outweigh the cost i.e., benefit = 5 people live, cost = 1 person dies, therefore the net benefit is 4 lives.

#### **Deontological Approach.**

To apply deontological ethics to this scenario, the action must be evaluated. The consequences of the action can be ignored. The action is “flipping the switch”. When considering if flipping the switch is immoral, a deontologist would consider if the action of killing someone is moral as pulling the switch is effectively killing someone. Therefore, a deontologist would do nothing in this scenario and the five people would die.

#### **Virtue Ethics Approach**

By focusing on the moral approach to the conundrum, the result of the trolley problem is much more complex. Someone applying virtue ethics does not have any interest in whether you save five lives or one. Remember the point of following a virtue ethics approach is about the development of a virtuous character. Therefore, the evaluation from the standpoint of a virtue ethicist is about identifying who you are as a person in responding to the situation. The question would really be whether your action or decision reflected virtuous characteristics like compassion, valuing life, acting in fairness, etc. Virtuous characteristics are diverse, and the ranking of these character traits is heterogeneous leading to possible several solutions.

For example, someone who values saving the most lives will flip the switch and steer the trolley away as it is simply the kind of thing a virtuous person would do. However, some would highlight the damage done to your character by taking this course of action. In comparison, suppose the single person on the track who would die if you threw the switch is your girlfriend or boyfriend. You have the opportunity of saving them at the cost of the five other people on the second track. In this case you may not flip the switch as you value love as an important virtue.

Although it is best to note that this is not an exhaustive set of solutions under virtue ethics as it will depend on the characteristics underlying what an individual considers as virtuous.

### Conclusion

No clear decision exists under all three theories.

The trolley problem outlined in Example 11.1 is often an introductory example used when learning ethics. The trolley problem is a question of human morality and a key example of where actions, intentions, and consequences can be considered. There is no single correct answer, and there are many ways of thinking through the dilemma.

One key issue the trolley problem often does not consider the hypothetical bias caused by a hypothetical problem. When faced with an actual variation of the trolley problem, our approach can change depending on the circumstances. The result is forced decision-making. A second limitation involves the problem morphing into a situational ethics approach where the ethical decision-making is contextual or dependent on a set of circumstances.

*The Trolley Problem* (Season 2, Episode 5) of *The Good Place* illustrates the challenges of the trolley problem. You can view the scene at this [external Youtube link](#). The xkcd comic in Figure 11.3 highlights the situationism of the trolley problem.

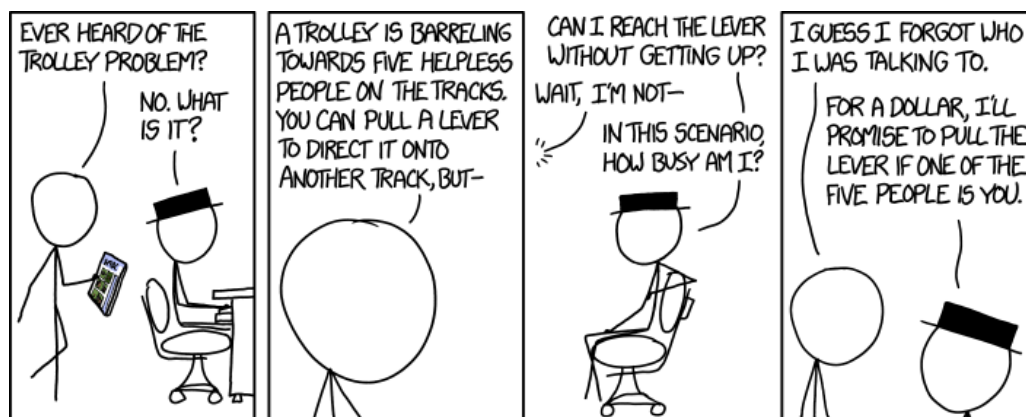


Figure 11.3: [Trolley Problem](#) by xkcd  
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If you are interested in reading more about the trolley problem, consider reading [this Conversation article: The trolley dilemma: would you kill one person to save five?](#)



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## Example 11.2

### The Trolley Problem Reframed.

The scenario adapted from [Andrade, \(2019\)](#).

*“A transplant surgeon has five patients, each in need of a different organ, who will each die without that organ. Unfortunately, there are no organs available to perform any of these five transplant operations. A healthy young traveller, just passing through the city the doctor works in, comes in for a check-up. During the check-up, the doctor discovers that his organs are compatible with all five of the dying patients. Suppose further that if the young traveller were to disappear, no one would suspect the doctor.”*

### What do you do?

This example is a more extreme version of the trolley problem that is often discussed in health economics and medical fields which has the same premise of saving five people at the cost of losing one person. However, this scenario can also be considered as a dilemma of killing one person or killing five people.

### Utilitarian Approach.

Under the utilitarian approach the result would be the same as the initial trolley problem in Example 11.1 – the doctor should sacrifice one person to save five thereby minimising the number of deaths.

### Deontological Approach.

Under deontological ethics, the scenario is more complex. The doctor has several duties but there are two we can use to highlight the point; (1) the doctor has the duty to help the five-transplant patient, and (2) the doctor has a duty to “do no harm”. This can be seen as a conflict in duties. Consequently, we would need to consider the trade-off between positive and negative duties. A positive duty is a duty to take an action. A negative duty is a duty to NOT take an action. In this situation the positive duty would be to save the five transplant patients whereas the negative duty would be to do no harm to others. In most instances the negative duty would be prioritised over the positive duty – and in this case the inaction of the doctor to save the lives of the transplant patients would not be deemed unethical.

### Virtue Ethics Approach.

Comparable with the initial trolley problem, the solution for virtue ethics is not clear cut and therefore we cannot designate a morally correct action. The result of the decision would reflect the virtues by the individual decision-maker.

### **Conclusions and Comparison to the Initial Trolley Problem**

When the general public is provided with this scenario, the consensus for ethical theories and the general public is that it would not be ethical to kill the traveller ([Andrade, 2019](#)). Additionally, the wider philosophical community always conclude that it is unethical to sacrifice the traveller in this instance. Therefore, the result of this reframed trolley problem leads to an overall realisation that the opposite conclusion the opposite conclusion happens often in the initial trolley problem. In the initial trolley problem, the answer, the majority of people come to is that “you are going to flip the switch”.

This second reframed trolley problem with the transplant patients is a bit more extreme as an example to highlight the difficulties of ethical decision-making. This example emphasises the ethical grey areas of dilemmas and highlights why ethical standards exist for many professions. So ethical dilemmas are quite interesting in that sense. And there’s quite a few different ethical dilemmas we can consider in economics.

## **Example 11.3**

### **Academic Dishonesty**

Academic integrity is linked to moral integrity in how individuals determine what is right and wrong. Consider the situation where you hire someone to complete your assessment for you (known as contract cheating). Cost-benefit analysis provides a framework that highlights why a student might engage in academic dishonesty. In this instance, the benefit would be a passing grade and the cost would be the price paid to the contractor.

### **Utilitarian Approach.**

When taking a utilitarian approach to the decision, a student will cheat if the net benefit is

greater than zero.<sup>7</sup> However, this decision conflicts with ethical and moral decision-making under deontology and virtue ethics approaches.

### **Deontological Approach.**

Under deontological ethics, academic integrity is a duty to uphold, and the action of cheating is considered wrong. This results in the conclusion that is not socially acceptable to cheat.

### **Virtue Ethics Approach.**

Under virtue ethics, choosing to act with integrity, honesty and academic excellence are all virtues that would discourage contract cheating.

### **Conclusion.**

Consequently, the impacts of ethical decision-making can be seen in the decision-making of university students around the globe.

## Why does Ethics Matter to Economics in General?

Policy analysts are required to weigh up the relative merits of alternative policy responses to any given problem. To do this in a systematic fashion, policymakers must establish a criteria for judging each alternative to assess the relative expected performance of each possibility. In cost-benefit analysis this is done by calculating the net social benefit using the net present value decision rule. However, a CBA analyst is not often the decision-maker or policymaker who provides the final judgement on whether a policy, project, or program goes ahead. Policymakers often use three key criteria when evaluating their options

- 1) Efficiency
- 2) Equity
- 3) Administrative simplicity

Taken together these three criteria lead to quality, ethical and timely decision-making.

Additionally, ethics is important to economics as each decision we face may involve an ethical or moral dilemma. For example, the economics of climate change is inseparable from social ethics as decision-makers need to find a balance between economic growth, the welfare of society (present and future) and the environment. Consequently, social understanding and ethics are core to well-rounded choices.

## Ethical Dilemmas at the Forefront of Economics Outside

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7. Note: there are arguments that there are significant negative impacts that are underestimated by students including, but not exhaustive – undermining the students learning, the penalties and consequences of being caught, and reputational impacts.

## of CBA

There are many instances of ethical dilemmas in economics. Some examples for consideration are highlighted below:

- The economics of climate change – it is hard to disentangle the impact of climate change and the requirements or obligations related to climate interventions (now and in the future).
- The effects of globalisation on poor countries – taking advantage of workers in poorer countries including the use of child labour or slave labour to produce goods and services for consumption in richer countries.
- Wealth and income inequality issues – both pre and post COVID-19 discussion on wealth and income inequality has been at the forefront of global economic conversations. Policy in many countries centres around the redistribution of income to assist the poor. There are moral arguments for aiming to reduce income inequality based on fairness, compassion, and generosity (virtues) to move people out of poverty and even are sometimes argued that it is in the self-interest of a country (like Covid payments to ensure economic growth does not contract significantly). This however can conflict with political rhetoric of governments creating a dilemma for decision-makers.
- Quality of life – often related to health and development economics, quality of life focuses on the ethical dilemma of how we value a life or value quality of life, especially when populations are significantly heterogeneous.

## Reflecting

The three ethical theories discussed in this chapter illustrate that motivations behind decision-making are complex. Cost-benefit analysis is a formalised framework for utilitarian ethics; however, it is important to consider various ethical stances in a CBA as the outcome may not lead to the appropriate decision. This is especially the case when underrepresented groups or those unable to advocate for themselves may be impacted by a policy, project, or program.

	Utilitarian Ethics	Deontological Ethics	Virtue Ethics
<b>Definition</b>	<ul style="list-style-type: none"> <li>The greatest good for the greatest number of people.</li> </ul>	<ul style="list-style-type: none"> <li>The action is right or wrong based on duties or rules. The consequences of the action do not matter.</li> </ul>	<ul style="list-style-type: none"> <li>Focuses on the cultivation of virtues and the moral character of people.</li> </ul>
<b>Application</b>	<ul style="list-style-type: none"> <li>Deciding based on what will benefit the majority to maximise the benefits to society.</li> </ul>	<ul style="list-style-type: none"> <li>Identifying one's duty and acting accordingly.</li> </ul>	<ul style="list-style-type: none"> <li>Deciding based on characteristics that make a virtuous person.</li> </ul>
<b>Strengths</b>	<ul style="list-style-type: none"> <li>Simple basis for formulating and testing policies.</li> <li>Objective way of resolving self-conflict.</li> <li>Result orientated.</li> </ul>	<ul style="list-style-type: none"> <li>Set of clear rules in the decision-making process based on natural moral laws or duties.</li> <li>Based on reason and not subjectivity.</li> <li>Emphasises the importance of every individual.</li> </ul>	<ul style="list-style-type: none"> <li>Not bound by rules.</li> <li>Personal – “Should I do this” approach.</li> <li>Emphasis on moral development.</li> </ul>
<b>Weaknesses</b>	<ul style="list-style-type: none"> <li>It is not always possible to predict the outcome of a decision and the consequences may extend beyond the time frame.</li> <li>Utility measures are hard to effectively determine.</li> <li>Harming a minority and benefitting a majority does not build fundamentally sound relationships.</li> <li>Should morality be tied to happiness?</li> </ul>	<ul style="list-style-type: none"> <li>Duties must be agreed upon. There may be disagreement about the principle involved in the decision.</li> <li>The possibility of making a “right” choice that has bad outcomes.</li> <li>Possibility of a conflict in duties.</li> <li>Duties can change over time.</li> <li>Moral laws can differ across societies.</li> <li>Underestimates the role of utility in decision-making.</li> </ul>	<ul style="list-style-type: none"> <li>Misses the importance of obligations.</li> <li>Potential for conflicts of virtues.</li> <li>Does not provide a direction for the problem at or decision being evaluated.</li> <li>There is no general agreement regarding what good virtues are.</li> <li>Can be often considered “situational ethics”</li> </ul>

## Revision



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## Summary of Learning Objectives

1. Social and ethical issues in economics are often related. Society reflects the ethics and morals of the time. Understanding ethical perspectives in decision-making enhances the results from “doing” economics.
2. There were three normative ethical theories covered: (1) Utilitarianism which is most aligned with CBA and focuses on achieving the greatest benefit for the greatest number, (2) Deontological ethics is focused on whether the action is right or wrong based on rules or duties, and (3) Virtue ethics focuses on what characteristics make a virtuous person such that decisions should follow good virtues.
3. The goal of this chapter was to compare the results from a utilitarian (CBA) perspective of decision-making to the alternative theories of deontology and virtue ethics. This highlights the importance of the consideration of ethical perspectives ensures that distributional impacts are appropriately identified and evaluated in CBA.
4. Cost-benefit analysis is a formalised framework for utilitarian ethics. However, it is important to consider various ethical stances in a CBA as the outcome may not lead to the appropriate decision.

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# PART 4: SHADOW PRICING

This part covers shadow pricing using four key methods.

- (1) Benefit Value Transfers
- (2) Alternative Pricing Methods
- (3) Revealed Preference
- (4) Stated Preference

Upon completing these readings and activities, students should be able to create a full social cost-benefit analysis including market and non-market impacts.



# CHAPTER 12: NON-MARKET VALUATION METHODS

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## Learning Objectives

**After completing this chapter, students should be able to:**

1. Define total economic value.
2. Identify types of goods including public goods, common goods, and mixed goods.
3. Value impacts using alternative market pricing methods.
4. Compare and contrast revealed and stated preference approaches to non-market valuation.
5. Implement and evaluate non-market valuations.

## Introduction

Continuing with the valuation of benefits and costs, we come to the final key concept – non-market valuation. It has been assumed that all impacts of policies and programs can be measured using market prices, or when markets are distorted, it is possible to adjust the observed market prices to reflect the true economic value of a good or service. However, this is not possible in all cases of market failure. Specifically, this chapter focuses on how to value goods and services when the appropriate market is absent. i.e., goods and services that are not traded on markets or cannot be traded on markets resulting in no observed market price.

In this chapter, we will explore methods for ascertaining the economic value of a good or service in

situations where a market price is not available. The approaches discussed are particularly useful for policy or projects with social, health, or environmental aspects. In particular, non-market valuation methods are useful for evaluating intangible impacts, such as national pride, climate abatement, pollution costs, public goods, and common goods. Consequently, non-market valuations are more common in public sector CBA, where the government is evaluating a policy or project. Specifically, the government is often interested in projects that may have wider intangible impacts or the resource is not provided by the private sector.

To being our approach to non-market valuations, we first need to understand the concept of *total economic value*.

## Total Economic Value

Value and price are two different concepts in cost-benefit analysis. The price is the amount economic agents are willing to pay for a good or service on a market. The economic value is the benefit derived from the good or service. In the absence of market distortions and market failures, the economic value and the price would be equivalent. However, economic value and price are often not equivalent if we observe market failure, market distortions, or market absence. For example, many environmental goods are not traded on markets and therefore there is no market price that can reveal the willingness-to-pay to consume the environmental good or service. Hence, we often refer to the total economic value in cost-benefit analysis, which aggregates all benefits from the use of a resource.

Total economic value is a concept that is key to cost-benefit analysis. Total economic value refers the value derived from a resource (such as the environment). The total economic value captures the overall economic value of the resource to society. There are three components to total economic value highlighted in equation (1).

$$\begin{aligned} \text{Total Economic Value (TEV)} &= \text{Use Value} + \text{Non-Use Value} \\ (1) \qquad \qquad \qquad &+ \text{Option Value} \end{aligned}$$

**Use value** consists of *direct use* value and *indirect use* value. Direct use value can be from consumptive uses and non-consumptive uses.<sup>1</sup> For example, if we consider a national park consumptive uses may include catching fish for food or using trees as wood for fires. Non-consumptive uses include hiking and birdwatching. Non-consumptive uses do not diminish the availability of the resources for others, whereas consumptive uses diminish the availability of the resource in the future. In these instances, an economic agent is deriving utility from direct use of the resource capturing recreation values.

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1. By consumptive uses we refer to the use of a resource for the purpose of consumption only.

Indirect use values are the benefits derived from the resource without actually “using” the resource directly or being near the resource. Coming back to the example of the national park this would include climate regulation, air and water purification, biodiversity benefits, etc. Estimating indirect uses is one of the biggest challenges faced by CBA analysts.

**Non-use** value captures *existence value* and *bequest value*. Existence value is the value attained by economic agents by knowing that a resource is conserved and will continue to exist. Within the national park example, this would be the knowledge that the parkland and its wildlife is protected even if you never visit the location. This is especially relevant for threatened or endangered species of flora and fauna. Similarly, bequest value is value gained from preserving the resource to be passed onto future generations, even if those future generations choose not to utilise the resource itself.

**Option value** reflects the value placed on the ability to use the resource in the future. The option value should capture the potential future benefits from the resource. Similar to use values – option value can subsequently be separated into direct and indirect uses.

The components of total economic value are illustrated in Figure 12.1 below:

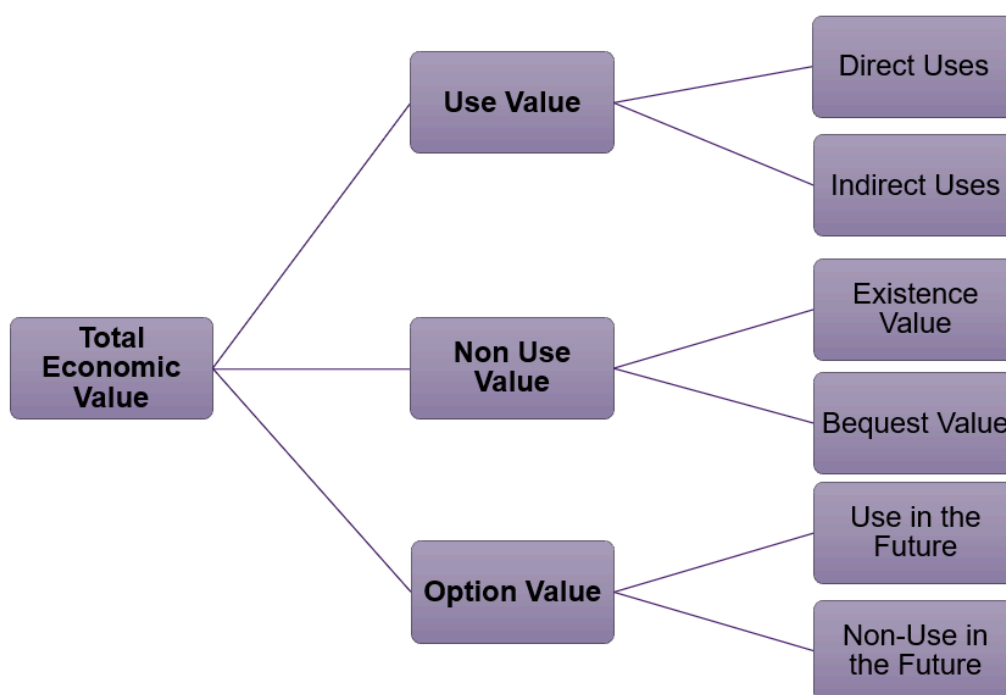


Figure 12.1:  
Components of  
Total Economic  
Value (TEV)



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Obviously, when apply shadow pricing to non-market goods and services, it is much more challenging than adjusting the observed market prices as seen in [Chapter 8](#). It is crucial to capture all aspects of the total economic value in the approach to shadow pricing.

Total economic value has implications for CBA. Categorically speaking, the implications relate to identifying the appropriate shadow price to be used in the social CBA. When dealing with non-market goods and services the value of the good is not reflected in market prices. The approach to the non-market value for a particular good or service under evaluation requires consideration of the role of use, non-use, and option values for the underlying resource. This represents a challenge for CBA analysts. Consequently, the type of non-market valuation methodology will relate directly to the aspect of total economic value we choose to identify and estimate, which is also dependent on the type of good the resource can be categorised as.

## Types of Goods

When approaching non-market evaluation, it is important for the analyst to think of any resource or commodity as lying on a continuum between a pure public good and a pure private good. Usually, economists define goods based on their level of excludability and rivalrousness in consumption:

- **Excludability:** If an individual can be prevented from consuming a good or service, it is considered excludable.
- **Rivalrous:** If an individual's consumption of a good diminishes the availability of the good for others to consume, then it is considered rivalrous.

All goods can lie on the continuum between pure private goods and pure public goods. However, for simplicity, we identify four key categories for goods outlined in [Figure 12.2](#): (1) private goods, (2) club goods, (3) common goods, and (4) public goods.

	Excludable	Non-Excludable
Rivalrous	<b>Private Goods</b> Food, clothing, cars	<b>Common Goods</b> Fish, timber
Non-Rivalrous	<b>Club Goods</b> Swimming pools, cable TV, toll roads	<b>Public Goods</b> Street lighting, air, national defense

Figure 12.2: Types of Goods Based on Excludability and Rivalrousness

- **Private goods** – are excludable and rivalrous. For example, mobile devices and laptops. These are purchased in stores (excludable) and when you purchase the device the quantity on the market decreases (rivalrous).
- **Club goods** – also known as mixed goods, are excludable but non-rival. For example, toll roads

are excludable via the use of a paid toll, but are non-rival as your use of the toll road does not decrease the availability of the road to other users who have also paid the toll.

– **Common goods** – are non-excludable, but rivalrous. For example, the fish stock in the Pacific ocean is a common good. Everyone can fish from the Pacific ocean (non-excludable). However, as the fish stock is taken from the ocean the number of fish available decrease, depleting the stock of fish over time (rivalrous). Common goods are often affected by the tragedy of the commons.

– **Public goods** – are non-excludable and non-rival. A good example of public goods is street lighting. You cannot be excluded from using a streetlight (non-excludable) and when using the streetlight, you do not diminish the availability of the light for other users of the light (non-rivalrous). Public goods are subject to free-rider problems.

As non-market goods and services are those not bought or sold directly on markets and therefore do not have an associated market price, they tend to fall into the categories of public goods or common goods. For example, common goods include beaches and national parks. Public goods include clean air and street lighting.

To capture the true net social benefit in a policy or project, it is therefore essential for an analyst to capture the impacts of common and public goods as part of their analysis.



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## Non-Market Goods and Services in CBA

When goods and services have no market, we still need to evaluate the impact of these goods and services as part of the evaluation of a policy or project. Consequently, shadow prices are used for valuing goods and services not actively traded on markets. For example, we often estimate shadow prices for:

- Externalities
- Public Goods
- Common Goods

Ideally, when implementing non-market valuation into CBA we are attempting to value benefits such as nature, recreation, water quality, climate abatement, prevention of disease, value of life, etc. When dealing with non-market costs we are trying to value air pollution, noise pollution, light pollution, environmental degradation, overfishing, etc. Inherently, these non-market benefits and costs are difficult to measure. By



their nature there is no direct market for determining their economic value of these goods and services, and thus the appropriate shadow price is hard to determine.

To ensure social surplus is maximised effectively, governments see a need to regulate the private market or undertake public expenditure in areas that are neglected by the market. The government tends to be the supplier of public goods, as the private sector has no incentive to produce the good or service. The result is that the government therefore needs to know which goods to provide as public goods to maximise the use of public sector resources and hence non-market valuation is necessary.

## Challenges of Non-Market Valuation

Non-market goods and services are also important for cost-benefit analysis. Even though non-market goods and services are not traded on markets, evaluating them as part of a CBA is crucial to calculating the total economic welfare. So even though we do not know the price, we still need to take into account the economic value of non-market goods and services.

If non-market goods and services are excluded from a social CBA, it introduces omission bias into the estimation of the net social benefit. It is crucial to note, that the investor CBA perspective would ignore the role of non-market impacts.

Consequently, an analyst is likely to encounter non-market valuation challenges. If project inputs and project outputs are not fully accounted for in a social CBA, it is not possible to reach allocative efficiency.

## Approaches to Non-Market Methods

There are many ways to approach non-market valuation as highlighted in Figure [12.3](#). As mentioned in [Chapter 7](#), benefit value transfers are a good starting point for evaluation of non-market benefits and costs.

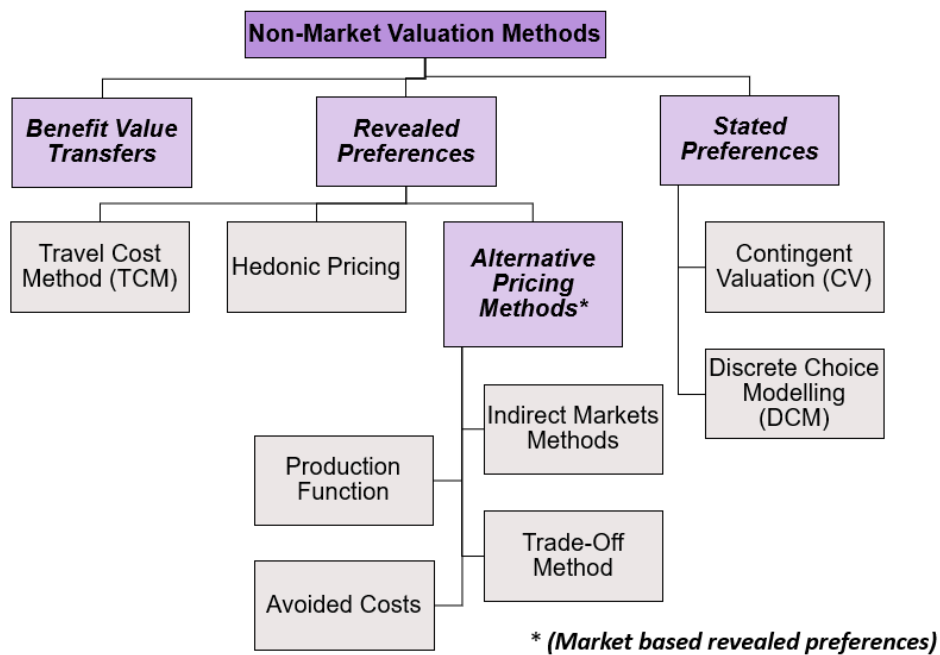


Figure 12.3:  
Subcategories of  
Non-Market  
Valuation  
Methods

## Benefit Transfer Methods

Most non-market valuation methods are technically complex, costly, and time consuming to implement. In the context of most CBA preparations, it is usually not be feasible for an individual department to undertake its own non-market valuation study for an individual project or policy. However, this does not necessarily mean we cannot attach a monetary value to the relevant non-market costs or benefits. Numerous non-market valuation studies have been compiled around many parts of the world. This means that it is possible to ‘borrow’ an approximate value (or a range of values) from other studies in similar situations – known as *benefit value transfers*.

Drawing directly on benefit transfers discussed in [Chapter 7](#), there is extensive research on non-market valuations for common externalities and public goods. Prices such as the social cost of carbon, tobacco externalities etc, have utilised non-market valuation methods to calculate the impact or economic value used in analysis. Meta analysis often highlights specific methodological approaches. It is possible to utilise benefit transfers from existing research – however if we want to adjust or improve these plug-in values it is necessary to understand how to implement non-market valuation methods. To evaluate the existing literature for utilisation for a project currently under consideration, it is important for an analyst to understand the methodological approaches to non-market valuations, including their advantages and disadvantages.

## Alternative Pricing Methods

Alternative pricing methods for non-market valuation using involves find alternative pricing mechanisms from already available information. There are four key alternative pricing approaches; indirect markets, opportunity costs, avoided costs, and production.

## Indirect Markets (Market Analogy Method)

This method is often used by the government sector to determine how much of a good or service the government needs to supply. Examples of this method include education, public housing, and healthcare. To implement the indirect market method, we begin by finding similar goods and services in a private market. The good or service must be comparable to the public good or service we are trying to value as part of the public project. Once an appropriate market is identified, we can use the information on the private market to estimate the value of the good or service if it was provided publicly by the government. Specifically, we can utilise the information on willingness-to-pay in the private market to identify what the price and quantity would be in the public market. The data from the private market is then used as a surrogate for the publicly provided good if their markets are similar. After analysing the similar market, it can be determined if the market price of a comparable good in the private sector can be an appropriate shadow price for the good used in the public sector.

### Example 12.1

#### Example – Indirect Market for Public Housing

Suppose the government wishes to provide some public housing. In this instance the government is providing rental housing lower than the market price. Suppose we observe the following information on the rent in the two markets:

Public Housing Rent: \$1,750 per month

Private Housing Rent: \$2,500 per month

Those who require public housing are not likely to value the housing at \$2,500 per month, but they will value it above \$1,750 per month. Therefore the willingness-to-pay for the public housing will lie between \$1,750 and \$2,500 per month. This information can then subsequently be used to determine how the government should value public housing when considering similar projects.

Disadvantage of this approach include:

- Requires the tastes, preferences, and quality to be the same between the consumers of the public good and the private good.
- Using private sector revenues would also often underestimate the benefits as it ignores the consumer

surplus.

## Trade-off Method (Opportunity Costs)

We already know that CBA analysts can use opportunity costs to evaluate a policy or project. Opportunity costs can also be used to evaluate non-market impacts. In the past we have looked at how to value time saved and the value of statistical life using wages. For example, we can use labour market wages to value time saved from reduced traffic congestion for road construction projects.

Disadvantage of this approach include:

- Using wages ignores other potential benefits and is subject to market failures. For example, some people may be unable to change their working hours each week, or firms may not be paying their employees their marginal social product.
- Using after tax wages may not effectively capture the true opportunity cost as it ignores individual preferences and the role of before-tax earnings on decision-making (Whittington & Cook, 2019).
- Using after tax wages ignores benefits from the project related to and the impact of taxes on preferences.
- It ignores potential for multitasking – for example people could be working while waiting or travelling resulting in the CBA underestimating the effects.
- Makes the assumption that people value the many uses of their time the same. However, the value of time saved travelling, time at work, and time spent in leisure activities are often valued differently based on personal preferences.

Consequently, there are quite a few disadvantages of this method when using wages as the opportunity cost. Analysts usually cannot know for sure how trade-offs are made and whether using wages would capture the full opportunity cost involved.

### Example 12.2

#### Trade-Off Method – Value of Statistical Life

Government health and safety programs often need to obtain a monetary value for lives saved after implementing a policy or program. This is referred to as the value of statistical life (VSL).<sup>2</sup>

It is possible to use the trade-off method to calculate a VSL in three ways:

- 1) *Foregone Earnings Method* – the lives saved is equal to the person's discounted future earnings. This method is often used in compensation cases within the legal context. There are ethical and moral limitation of this method that have led to a general consensus that this method is inappropriate. The foregone earnings method provides of higher values for higher income earners and lower values for low-income earners (discriminating between professions). There are also elements of gender biases as women often self-select into lower income professions. Furthermore, for retired people the result of VSL may be negative. This is problematic if we consider healthcare interventions where older people need more interventions, but the value attached to their statistical lives is lower.
- 2) *Simple Consumer Purchases* – willingness-to-pay for a reduction in risk. Specifically, we evaluate the purchase of safety equipment or other life-saving devices to reduce the risk of death. If people are indifferent between paying an extra \$300 to reduce the probability of death by 1/10,000 – then their life is valued at \$3 million (price paid / risk reduction =  $\$300 / (1/10,000)$ ). This is a revealed preference.
- 3) *Simple Labour Market Studies* – comparing the risk premium for taking a risky job over a less risky job. If a person is willing to forgo an extra \$3,500 per year to increase the probability, they will not have a fatal accident at work by 1/1,000 – then the person values their live at \$3.5 million or more (forgone earnings/ risk reduction =  $\$3,500/(1/1,000)$ ). This is also a revealed preference.



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2. For a discussion of the ethical implications of using a VSL refer to [Chapter 11](#).

## Avoided Costs (Mitigating Behaviours)

People can place a price on a non-market impact through the process of paying to avoid or mitigate the impact. For example, climate abatement costs, or double glazing windows to reduce noise pollution. The transactions associated with avoided costs can be used as a proxy value in the CBA.

Disadvantage of this approach include:

- The avoided cost method has been criticised for using price to proxy for economic surpluses, and consequently underestimating the true value of the non-market good or service (Baker and Ruting, 2014).

## Production Function

Production function methods involves modelling consumer behaviour. The production function approach involves investigating changes in the availability or consumption of goods and services that are substitutes or compliments of the non-market good or service of interest. For environmental goods and services, the contribution to the final market production is captured.

### Case Study – Beekeeping and Production Function

If we go back to the example of beekeeping as a positive externality from [Chapter 8](#). It is possible to use the production function method to value the benefit of the effects of bees as pollinators and pollination services on total crop output, capturing relative benefits to other goods and services outside of honey production. This method when applied to the benefits of pollination is considered highly accurate ([Gallai, 2016](#)).

Disadvantage of this approach include:

- One off the issues with using the production function method is the requirement for full information regarding the contribution to production. As there is incomplete scientific understanding of the environmental impacts or changes it can create bias in the estimates (Baker and Ruting, 2014).

## Alternative Market Pricing Overall

There are some common advantages and disadvantages of using alternative market pricing approaches to non-market valuation.

- Advantage: Provides a non-zero valuation of the non-market good or service which would otherwise not be included in a CBA. It's better to have included an impact as a non-zero value than excluded it from the CBA by setting the value equal to zero.
- Disadvantage: Issues with omitted variable biases. Using alternative market approaches may not capture the non-use value or option value of a good or service, leading to omitted variable bias.
- Disadvantage: There is opportunity to introduce selection bias based on the approach used. For example, if we use an inappropriate market for the indirect market method.

Furthermore, all the alternative pricing methods relied on indirect approaches to pricing. Consequently, these methods are examples of *revealed preferences* – meaning that individual's preferences are revealed by their interaction on the market.



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## Stated Preferences Versus Revealed Preferences

When using non-price related methods to value non-market benefits and costs, we often rely on revealed or stated preference approaches for valuation. A preference is the order that a person gives to alternatives based on their relative utility. By ranking their preferences an individual can make the optimal choice that maximises their utility. Expanding on this, *revealed preferences* are preferences revealed by studying actual decisions people make (measured by their actions) to determine the value of non-market goods and services. *Stated preferences* approaches to non-market valuation are survey-based approaches to valuation. For stated preferences, individuals are asked about their willingness-to-pay or willingness-to-accept under a series of hypothetical decisions.



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## Revealed Preference Methods

Revealed preferences are founded in actual behaviours that can be observed and provide a reliable estimate of non-market valuations. However, non-use value is often not reflected in the observed behaviours in the market. Therefore, revealed preference methods best for evaluating non-market impacts that are heavily weighted towards use values.

There are two key revealed preference methods that are used to study the actual decisions people make regarding the non-market goods and services; (1) hedonic pricing, and (2) travel cost method.

### Hedonic Pricing Method

The hedonic pricing method assumes that the value of non-market goods and services is partially reflected in the price paid for an underlying asset, item, good, or service. By deconstructing the price of a multiple attribute market good, hedonic pricing can capture the price of non-market attribute or aspect of the good. Systematic variation in the price of the underlying asset allows the analyst to capture the value of the non-market characteristic or resource under evaluation. This allows for an implicit price for each attribute the consumer is willing to pay including those attributes that are not traded on markets. For example, we can use hedonic pricing to capture the non-market value of noise pollution, proximity to beaches, or recreational facilities through the price paid for housing.

To estimate a hedonic pricing model, an analyst identifies a function with price as the dependent variable and the attributes of the good as independent variables, including the non-market attribute in question. For example, if we were interested in how the view impacts the price of a house, we may choose to estimate the following multiplicative model:

$$P = SIZE^{\beta_1} \times BEDS^{\beta_2} \times VIEW^{\beta_3} \times QUALITY^{\beta_4}$$

where SIZE is the size of the land the house is on, BEDS is the number of bedrooms, VIEW is the view of the house (the non-market attribute we wish to value) and QUALITY is the quality of the building. This function would be referred to as the hedonic price function or implicit price function. Converting this multiplicative model into logarithms and regressing the results will give the elasticities i.e., the coefficient on VIEW ( $\beta_3$ ) would tell us the WTP for an average house in response to a 1% increase in the “quality of the view” – the non-market attribute. Consequently, we can observe the change in the price of a house that results from a unit change in a particular attribute (i.e., the slope). This is called the *hedonic price, implicit price, or rent differential* of the attribute.

After identifying the hedonic price, the second step to evaluating the non-market attribute is to use the estimates for the WTP to derive the demand for the specific attribute in question. When implementing the second step, we should control for preferences which can be captured by factors such as income and other socioeconomic variables. For example, we could estimate the following:

$$P = f(VIEW, INC, SOCEC)$$

where INC is the household income, SOCEC is a vector of socioeconomic characteristics (such as age, gender, postcode, etc.). Once formulated, we can use the results from the estimated demand curve to



calculate any changes in consumer surplus as a result from a change in the non-market attribute of interest (in this case the view), by aggregating across all households.

There are two key advantages of the hedonic pricing method:

1. The underlying application is conceptually intuitive and utilises prices that can be observed on a market.
2. The results are based on revealed preferences which represent individual's *actual* behaviours. Therefore, this method offers a way to overcome problems related to omitted variable bias and self-selection bias.

There are quite a few disadvantages of this method:

1. The implication of the underlying non-market attribute being evaluated must be understood by the analyst. For example, people should know the amount of noise or the quality of the view when valuing these aspects using the hedonic pricing model.
2. All inputs in the regression model must be measured without errors to ensure the analysis is sound and there are no multicollinearity issues.
3. The functional form for the hedonic pricing function must be correctly specified.
4. There should be a sufficient number of data points to ensure a sufficient number of comparison points i.e., all possible combinations of attributes are available to each individual purchasing on the market.
5. The market price can adjust immediately to a change in the attributes that comprise the asset.
6. It assumes that the value of the underlying asset can be calculated through the sum of the attributes alone.

Points 2, 3, and 4 are considered econometric problems with model specification.

## Travel Cost Method

The travel cost method evaluates the expenses incurred travelling to make use of a good, service, or resource. The number of visits to a site is postulated to be a function of the travel cost and socioeconomic variables. The travel cost itself is a proxy for the price to use the good, service, or resource. The travel cost method is widely applied to recreational sites such as national parks, sporting fields, fishing, and tourism.

Suppose we wish to estimate the value of a national park. We expect that the number of visits demanded by an individual depends on the price ( $P$ ), the price of substitute activities ( $P_{sub}$ ), the individual's income ( $Inc$ ), and the preferences ( $Z$ ) of the individual such that we can estimate the following equation:

$$Visits = f(P, P_{sub}, Inc, Z)$$

The price of the visit must capture the full price paid for a person to visit the local park. In this instance it is more than an admission fee or entry fee. It should include all opportunity costs involved including time spent travelling, any overnight accommodation, parking fees, etc. The sum of all the incurred expenses or

costs to utilise the park count towards the total cost of the visit (the “price”). The total cost is then used in an explanatory variable to estimate the number of visits to the park – this measures the demand for the non-market good and service.

It is important to note that although the cost of admission into the facility being evaluated is usually the same, the total cost faced by each person varies. This allows for inference regarding the demand curve. Overall, using this method it is possible to estimate a demand curve for a good or service that does not have an underlying market. Once the demand curve is identified, we can apply the standard economic approaches to the evaluation of a CBA.

Estimating the demand schedule for a particular recreational site can be done in three easy steps:

1. Select a random sample of individuals or households within a defined boundary of the recreational site. These are the potential visitors.
2. Survey the households to determine their number of visits over a period of time including the cost of the visits, the cost of visiting other recreational sites, their household’s income, and other characteristics that may affect their demand (such as the number of children in the household).
3. Specify the functional form for the demand curve and estimate it using the data collected in step 2. Note that if the total cost replaces the price of the visit in the functional form, then quantity is a function of cost (and not the usual quantity as a function of price).

There are two key advantages of the travel cost method:

1. The demand curve is relatively easy to estimate once the data is collected.
2. Like the hedonic pricing method, the results are based on revealed preferences which represent individual’s *actual* behaviour. Therefore, this method offers a way to overcome problems related to omitted variable bias and self-selection bias.

The disadvantages of the travel cost method include:

1. The estimates are the WTP for an entire site and not a specific feature of the site. For example, in evaluating the national park, you would estimate the value of the park for hiking, fishing, and camping all together. Therefore, you cannot identify a value for a specific non-market aspect of the site.
2. Measuring total cost per visit is difficult as you also need to measure the opportunity cost. Opportunity costs need to be fully measured – which is complex.
3. Dealing with multipurpose trips – often people who travel for vacations to use sites may visit other facilities nearby. The travel cost method does not capture this effectively.
4. There are often low to zero value travel costs for locals who likely receive high benefits from the site.
5. Travel cost method is best for capturing use value (from those visiting to use recreational sites). It does not effectively capture non-use value (existence and bequest value).

## Stated Preference Methods

Stated preference methods involve asking individuals for their willingness-to-pay for a good or service using surveys. Usually, an individual is asked to make choices between various option sets. This allows an analyst to determine the value of an underlying good or service of interest for the CBA.

Stated preference are often considered less rigorous than revealed preference approaches. Stated preference approaches are often criticised due to the hypothetical nature of the questionnaires. However, more recent literature has highlighted that the results of stated preference are similar to those of revealed preference approaches (Baker and Ruting, 2014). Additionally, it is important to note that stated preference methods are better at capturing non-use and option values compared to revealed preference approaches.

There are two stated preference methods used in cost-benefit analysis: contingent valuation and discrete choice modelling.

### Contingent Valuation (CV)

Contingent valuation (CV) is the most common stated preference approach. CV involves asking people whether or not they would pay a set amount of money for the non-market good or service to directly elicit their willingness-to-pay to receive a good or willingness-to-accept to give up a good. Contingent valuation is useful for public goods where there is no obvious method to determine preferences of society – therefore the easiest method is to ask!

To implement CV there is a four-step process:

1. **Identify a sample** of respondents from the population – specifically those with standing in the policy or project.
2. Ask respondents **questions** about their valuations of a good.
3. **Use the responses to estimate the WTP or WTA** for the good using information from the survey.
4. **Extrapolate** the results to the entire population.

Advantages of contingent valuation include:

1. Encourages a non-zero valuation.
2. Does not rely on observing interactions in any markets.
3. Is better at valuing non-use and option values than revealed preference methods.
4. Can be applied to any underlying non-market good or service that requires evaluation.

Disadvantages of contingent valuation include:

1. Hypothetical bias – as the survey questions often involve hypothetical scenarios, the results may not

reflect the implications in the real-world. Therefore, the results are often context dependent.

2. There are differences between willingness-to-pay and willingness-to-accept caused by loss aversion and reference points prior to the survey.
3. Can be costly if it requires many surveys to get a true representation of the underlying non-market good or service being valued.
4. Non-commitment bias – those who are asked their WTP for a good or service may not need to commit themselves to *actually* pay and therefore we cannot capture the true WTP with certainty.



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## Discrete Choice Modelling (DCM)

Discrete choice modelling (DCM) estimates the implicit prices for the attributes of a non-market outcome. This is done by asking people to choose between options that are described at different levels of attributes and any costs they would have to pay. Essentially, DCM allows for respondents to provide distinct valuations across multiple dimensions to account for trade-offs on a discrete level. People are asked to make selections between pre-defined options that describe different levels of attributes along with any costs that would need to be paid. Participants of the survey then select their most preferred outcome from the set of alternatives.

Discrete choice modelling is a simple extension of CV where the participants no longer have an open-ended response. Hence, discrete choice modelling has become more predominant for valuing non-market goods and services. The advantages and disadvantages of DCM are the same as those listed for contingent valuation. However, there are some key additional advantages of DCM over contingent valuation including:

1. DCM provides an additional level of accuracy over contingent valuation as there is an experimental design that provides a set of choices to the survey respondents.
2. Opportunity to deal with multidimensional issues and trade-offs more effectively than contingent valuation.

Disadvantages of DCM relative to contingent valuation include:

1. Understanding of preferences – It can be complex for the respondents to understand between choices resulting in intransitive preferences. For example, if  $A > B$  and  $B > C$  then  $A$  should be  $> C$ .

But due to some misunderstanding, people can get confused and not provide transitive preferences.

2. Question fatigue – as the survey usually required more questions to ensure clear identification of the value of a good or service relative to the open-ended responses of contingent valuation.

## Where to From Here?

Once the approach for valuing the non-market good or service is selected and implemented, it is possible to implement an appropriate shadow price for use in the cost-benefit analysis. Figure 12.3 highlights the various methods for non-market valuation techniques. It is important for an analyst to consider the advantages and disadvantages of various methods when selecting which valuation method to use.

### Revision



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## Summary of Learning Objectives

1. Total economic value captures use value, non-use value and option value.
2. There are four key types of goods: (1) public goods, (2) common goods, (3) club goods, and (4) private goods. Goods are seen to lie on a spectrum between pure private goods and pure public goods – where the degree of excludability and rivalrousness determines the category.
3. It is possible to calculate a value for a non-market good or service using alternative pricing methods. Alternative pricing methods use alternative market prices to value the non-market good or service such as using indirect markets, the trade-off method measuring opportunity costs, avoided costs and production function approaches to value the underlying resource or attribute.
4. Revealed preference methods include hedonic pricing, the travel cost method, and alternative market pricing methods. These methods rely on observed behaviours and are very efficient in determining use value of a non-market good or service. Stated preferences are survey-based methods for evaluating choices and are better at capturing non-use values. The two survey methods discussed include contingent valuation and discrete choice modelling.
5. It is important for an analyst to evaluate the choice of non-market valuations. Implementing non-market valuations ensures we achieve the socially optimal outcome from a CBA through the use of appropriate shadow pricing.

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# PART 5: WRITING A CBA REPORT



# CHAPTER 13: GUIDELINES TO CBA REPORT WRITING

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## Learning Objectives

After completing this chapter, students should be able to:

1. Understand what makes a report an effective communication tool.
2. Create a CBA report including all relevant components.

## Guidelines to CBA Report Writing.

In this chapter, we discuss the details relating to how to write a CBA report. As mentioned in Appendix [Chapter A1: Context Matters!](#), there are 9 stages involved in the evaluation process for a CBA. When communicating the results, it is imperative that we bring all 9 components together into a report for the policymaker or decision-maker that requested the CBA.

## Why is a CBA Report So Important?

As we now understand, CBA is an important tool for decision-making. The results of the analysis conducted as part of the evaluation process is intended to inform the decision-making process. Therefore, it is important that the results are communicated in a manner that is useful to the decision-maker.

- From a private business perspective, the CBA report will provide an indication on whether a project has a sound business case, considering taxes, depreciation, and loans involved.
- From a government perspective, it allows for the evaluation of allocative efficiency by determining

the projects with the highest social net benefit (where the social benefit exceeds the social cost).

## Key Steps to be Included in the CBA Report.

As previously mentioned, we must ensure the report clearly outlines all 9 stages of the CBA process outlined below:

1. Specify the options or set of alternatives under consideration.
2. Decide whose benefits and costs count.
3. Identify the impacts and select measurement indicators.
4. Predict the impacts over the life of the proposed project, program, or policy.
5. Monetise all impacts (attach \$ values).
6. Discount future costs and benefits to obtain present values.
7. Compute the net present value (NPV) of each project.
8. Perform a sensitivity analysis.
9. Reach a conclusion.

However, it is not necessarily clear where to include the information for each of these steps in the report itself. There are no set rules for incorporation of these stages in the report. However, the following is suggested in Table [13.1](#) below:

**Table 13.1: Components of a CBA and Alignment with Report Structure**

Component of Report Body	Stage of CBA
1. Introduction	1. Specify the options or set of alternatives under consideration. 2. Decide whose benefits and costs count.
2. Methodology or approach	3. Identify the impacts and select measurement indicators. 4. Predict the impacts over the life of the proposed project, program, or policy.
3. Discussion of results	5. Monetise all impacts (attach \$ values). 6. Discount future costs and benefits to obtain present values. 7. Compute the net present value (NPV) of each project. 8. Perform a sensitivity analysis.
4. Conclusion	9. Reach a conclusion.
5. Recommendations	

## What to Keep in Mind When Writing the Report?

There are four aspects that should be clearly demonstrated within the body of report itself:

1. Scope of the problem. What policies will follow the implementation of the recommendations of the CBA from a public sector perspective. Provide an explanation on the need or importance of the project policy or program under evaluation. The background and relevance of the context – this should relay only the most important information that is relevant to the project, policy, or program under evaluation.
2. The analysis directly related to the decision-making – including any assumptions made and their implications.
3. The context in which the decision should be made – specifically how the CBA acts as a decision-making tool.
4. A clearly defined final recommendation – remember that decisions are made by policymakers. Recommendations are made by CBA analysts. A CBA is only one input into the decision-making process. In the real-world, the policymaker is responsible for the final decision. There are many factors that may influence the final decision to undertake the project from a resourcing, political, or social perspective.

## Report Structure – General Aspects.

Report writing often varies depending on the context for which the report is written. Many government departments and consulting groups will provide templates to use in a professional context. The examples provided in this chapter are for general information and to help improve your writing style. Some key things to note about reports:

- A good report has a clear structure and is written in sections (first level headings), with subsections (second level headings). This is very different to how you would approach an essay. In an essay you are developing an argument. In a report, the use of section headings and subheadings allows the reader to read only the perceived relevant sections of the analysis.
- Dot points are okay to use in a report – however you should not overuse dot points.
- Tables and figures are best to communicate numerical results (see Example [13.1](#) and [13.2](#)). Ensure all tables and figures have captions and headings. Remember the basics from your statistics and quantitative methods courses!
- Remember the basics of paragraph writing. For some assistance, refer to [this free online text by Williamson \(2021\)](#).

A general structure for a report includes the following components:

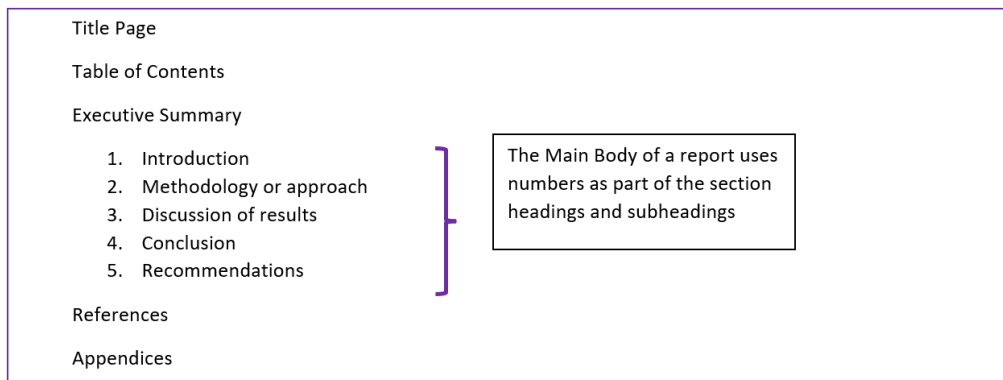


Figure 13.1:  
Example of the  
Sections in a  
Report

A report can also have additional sections to cover literature reviews, theoretical frameworks, list of figures, list of tables, and acronyms where appropriate. Only sections in the main body use headings and subheadings. The use of headings and subheadings is to provide a clear trajectory to the reader of your report.

## Title Page

The title page should include the report title along with the details of the authors.

If the report you are writing is for assessment purposes you should include the course code, student numbers and the word count of the final submission. An example of how you can format the title page is shown in Figure 13.2. Keep in mind that you can use Microsoft Word templates to generate a general report structure to make it easier to implement a report format.

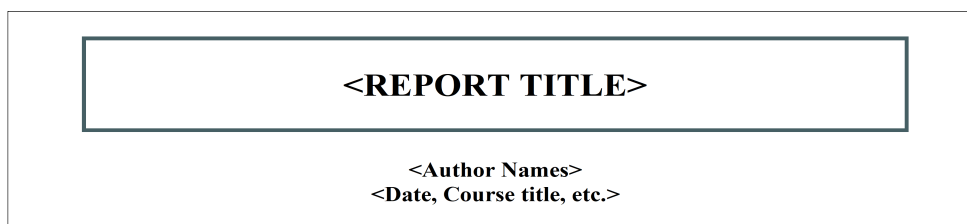


Figure 13.2: Title  
Page Suggestion

## Table of Contents

The table of contents should provide the reader with page numbers associated with various sections of the report. Usually, the table of contents captures list of the first level headings and often also the second level subheadings of a report. As a rule of thumb, third level subheadings are not usually provided in the table of contents unless the report is significantly large. An example of a traditional table of contents can be seen in Figure 13.3. Note the use of Roman numerals for the executive summary followed by standard numbering for the body of the report.

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Figure 13.3:  
Example Table of  
Contents.

## Report Structure – CBA Specific Aspects.

### Executive Summary

An executive summary in the context of a CBA should be a non-technical summary of the overall scope and purpose of the report. Within the context of CBA, the executive summary should cover the project under consideration (and any alternatives), the approach to the analysis, the main results, and the final key recommendation. This section of the report is usually written last.

In practice, an executive summary should not exceed one page. When writing a report for assessment purposes it is best to limit the executive summary between 100 -200 words depending on the total word limit of the assessment.

Note that the executive summary heading is not numbered, and page numbers start with roman numerals to indicate it is the preface of the report.

### The Main Body of the Report

Remember that the main body of the report should use headings and subheadings that utilise numbering. In the context of a CBA there are key elements that should be covered in each section:

#### 1. **Introduction**

The introduction should provide a brief summary of the report. In the introduction you should cover the relevant but brief background context for why the CBA is necessary, identify the options associated with the project under evaluation – which involves explicitly identifying the base case scenario or the



status quo. Finally, the introduction should also provide information on the context on how the CBA recommendations can inform the final decision.

The introduction is separate from the executive summary. The executive summary should give an overview of the whole report.

## 2. Methodology or approach

The methodology section will depend on the nature of your report. In the context of a CBA report, you should identify the approach to the CBA along with describing key variables and assumptions. Obviously, the approach to a private project appraisal would be different to the evaluation of a change in climate change policy or a healthcare intervention. However, there are some key components you should cover in this section:

- Highlight how the impacts are predicted and then monetised as part of the CBA.
- Provide information on the discounting approach used for the project.
- Identify with whether the analysis was conducted using real (constant year 0) or nominal values (accounting for inflation and/or growth rates).
- Include a clear indication on the decision rule that will be used to drive the recommendation process. This is key as the reader of the CBA may not have sufficient knowledge to infer why the recommendation is being made. Therefore, you should ensure that you provide a clear and concise understanding of the decision rule being adopted to evaluate the net social benefit.
- Outline any assumptions relevant to the calculations of impacts. However, leave discussion of the consequences of these assumptions to the discussion or conclusion section.
- Identify all the effects including those that were monetised as well as those that may have been excluded from the monetisation process due to difficulties.

## 3. Discussion of results

The discussion section of the report is often the longest and most detailed section. In this section you should critically analyse the findings of the analysis you conducted in the spreadsheet or CBA toolkit used.

In a CBA report you should ensure that you discuss:

- Provide a concise breakdown of the results including the key metrics for the evaluation. Remember that you may not need to report all aspects. However, tables and figures can be used to compress and synthesise information. It is also important to ensure that the magnitude of the results and the currency is reported in each table.
- Which project(s) should be accepted and why? Clearly emphasise any decision rules yes. Ensure this is outlined relative to the base case scenario or status quo.
- Would there be alternative public or private sector entities that may be interested in the project or may be opposed to the project undertaken.
- Are there any distributional impacts that should be considered i.e., are any stakeholders impacted un-equitably?

Finally, in this section you should also include the results of the sensitivity analysis you should have conducted (per [Chapter 9](#)). Every CBA should have a sensitivity analysis as there is considerable uncertainty regarding the predicted impacts. In the sensitivity analysis you should evaluate any of the inputs into the CBA that may significantly impact the estimated net social benefit. Influential variables should be clearly identified and the impacts of changes in those variables should be discussed – especially if there is a significant change to the net present value. Again, one of the easiest ways to present the results of a sensitivity analysis is the use of a matrix or table.

In terms of constructing the sensitivity analysis, it is often best practice to separate the those controllable(endogenous) and uncontrollable(exogenous) aspects of the project. For example, if we are considering a farming project a controllable component would be units of labour used, whereas an uncontrollable input could be the size of the crop as it depends on the weather the farm experiences.

Remembering that the sensitivity analysis allows us to somewhat account for uncertainty, you should ensure there is also a clear conclusion on whether the recommendation changes based on the sensitivity analysis conducted.

#### 4. Conclusion

Like the conclusion of an essay, the conclusion of the report should reinforce the relevant aspects of the report body to form an argument. The argument should directly support the recommendation to accept or reject the project relative to the base case scenario or status quo.

In writing the conclusion, you should not only refer to the results of the analysis in the previous section, but also set the results of the decision rule context of the literature and any limitations of the methodology used for the CBA.<sup>1</sup> Consequently, this section should highlight the impact of any assumptions made.

#### 5. Recommendations

The recommendations section of a CBA report provides an opportunity to suggest solutions to the implications of problems highlighted in the discussion or conclusion section of your CBA. The recommendations can be related to specific actions such as how to reduce risk or uncertainty with a project and/or suggestions for further research when impacts were excluded from the analysis.

Ensure your final recommendation is communicated in a way that the implications are clear to the decision-maker – again remember the communication of these results should be appropriate to the audience you are writing for. Consider whether the audience is informed in CBA, or if the reader is not aware of the method.

Ensure any assumptions, limitations, or areas for further investigation are highlighted in this section. If there were any specific impacts excluded from the monetisation process or strict assumptions were made,

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1. Specifically, you should identify whether similar projects resulted in the same conclusion and whether the assumptions are considered appropriate based on the relevant literature.

you should highlight these for the reader – especially if the assumptions may significantly change the net social benefit. If key impacts are excluded due to limited time for the evaluation of the CBA ensure you determine whether the results of the CBA would be an upper bound or lower bound estimate of the net social benefit.

Finally, provide a clear justification of the recommendation based on the decision criteria used – should the project be accepted, rejected, or even possibly improved. When considering more than one alternative projects, be clear on which project is preferred. The recommendation should also consider whether the evaluation of distributional effects (winners and losers) should be considered as part of the decision process. Specifically, when evaluating public policy using CBA it is important to consider the Kaldor-Hicks criteria as well as any possible unintended consequences from the implementation of a policy. At this point, it is also important to highlight any ethical or social implications of the final decision to ensure full information is conveyed to the decision-maker.

## The Difference Between Conclusions and Recommendations

There is an important difference between the conclusion and the recommendation sections of a report. Every report must have a conclusion section, but not all reports will have a recommendations section. A conclusion is based on the data analysed as part of the report. When including a recommendation section, you are reaching beyond the scope of the data analysed in the CBA. The length of both the conclusion and recommendation sections depends on the context of the CBA and the depth of analysis conducted.

## References and Appendices

All reports should have a reference list. It is important that you are consistent with your reference list formatting. The UQ referencing guide is helpful [for formatting and provides quality examples for all possible scenarios](#). For alternative institutions, it is best to refer to the relevant library resources. Remember that reference lists at the end of a report need to have the second line indented as shown in Figure 13.4.

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### Reference List

Baker, P. R., Francis, D. P., Hairij, N. N., Othman, S., & Choo, W. Y. (2016). Interventions for preventing abuse in the elderly. *Cochrane Database of Systematic Reviews*, 8. <http://doi.org/10.1002/14651858.CD010321.pub2>

Boardman, Greenberg, D. H., Vining, A. R., & Weimer, D. L. (2018). *Cost-benefit analysis: concepts and practice (Fifth edition.)*. Cambridge University Press.

Brent, R. J. (2015). Valuing the prevention of elder abuse. *Applied Economics*, 47(58), 6362–6373. <https://doi.org/10.1080/00036846.2015.1071471>

Figure 13.4:  
Reference List  
Formatting

Appendices are included after the reference list and should be labelled Appendix 1, Appendix 2, and so on. *When your report is for the purpose of assessment, ensure you check whether appendices are allowed or contribute to the word count.*

## Formatting

Formatting is an important aspect of writing a report. You should consider the font size, line spacing, margins, paragraph format, structure, and page numbers when writing your report. Remember that the report should be easy for the decision-maker to review and understand.

## Know Your Audience.

The audience of your report will depend on who commissioned the report. Before writing, consider the objective of the report and the context of those who will be reading the report. Again, at this point it is important to remember that a CBA analyst's role is *to make recommendations based on the analysis, rather than making decisions*. There are three main sectors CBA is written for: (1) private sector, (2) public sector, and (3) non-profit organisations.

### Private Sector

If the report is for a private firm, the report should be written from a financial/economic appraisal approach rather than a social CBA approach. Remember that in accordance with basic economics, firms seek to maximise profits. Keep in mind any possible reputational issues a project may cause. For example, if a firm is considering a factory there may be negative externalities such as pollution costs to society that can have a negative impact on the firm's reputation.

### Public Sector

If the government has commissioned the report, you should emphasise the social cost-benefit analysis results. Consider all non-market valuations used to correct market failures. Furthermore, it is important for a government perspective to identify distributional impacts and any "at risk" stakeholders.

### Non-Profit Organisations

Similar to the public sector not-for-profit organisations face a challenge not commonly found among their private sector counterparts. If the report is for a not for profit, you should consider all relevant aspects in the cost-benefit analysis from a social CBA perspective.

Keep in mind that the audience for many CBA's can also vary depending on the topic. For example, a cost-benefit analysis on healthcare interventions will be fundamentally different to a cost-benefit analysis on the provision of a public good by a government entity.

## Draft, Draft, Draft.

Like all things to do with writing, the first draft is never the finished product. Time should be spent reviewing, refining, and rewriting the report. Through engaging in the drafting process, you can refine the topic, purpose, audience, and context of the report.

### Example 13.1

As part of a CBA report, it is crucial to consider the display of information. For example, graphs can be useful in communicating the results of a sensitivity analysis. Suppose we return to example 10.4 from Chapter 10. An example of how the information from the partial sensitivity analysis could be graphed is illustrated in Figure 13.1 below.

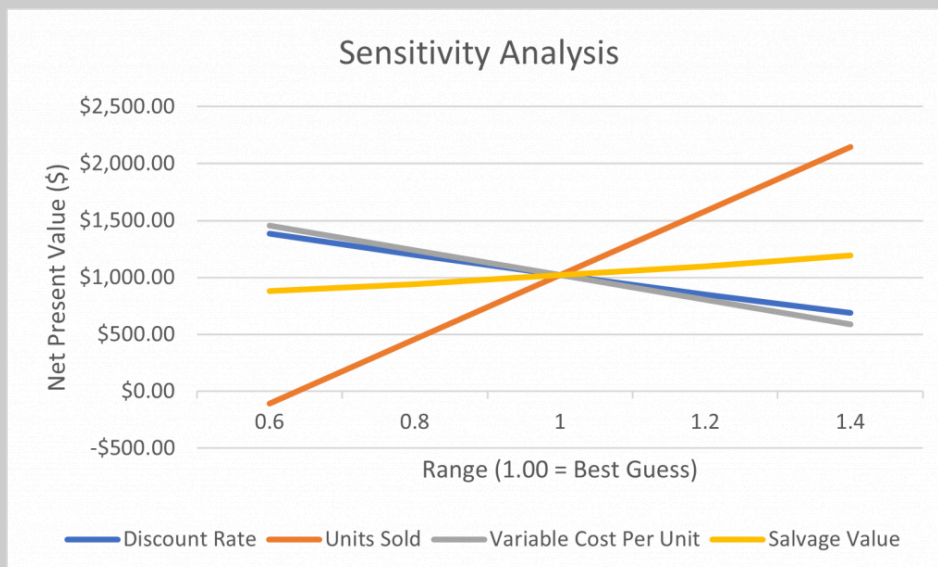


Figure 13.1:  
Graphing  
Sensitivity  
Analysis Using a  
Line Graph

Additionally, we can similarly plot the sensitivity analysis for the variables using a tornado graph

as shown in Figure 13.2. This type of graph shows the change in the NPV as a proportion of the best guess scenario.

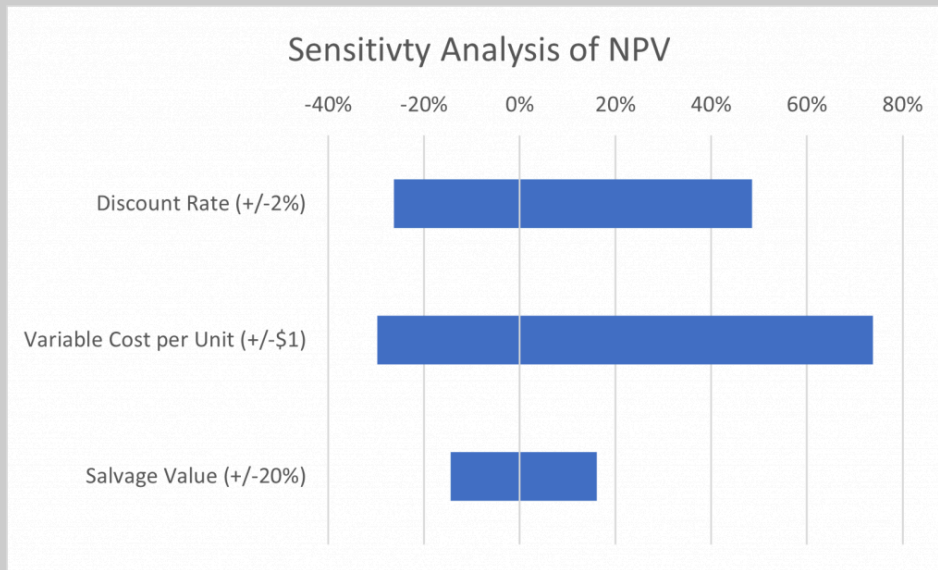


Figure 13.2:  
Example of a Bar  
Graph to Show  
Absolute Changes  
in NPV

## Example 13.2

As mentioned in Chapter 10, it is also worthwhile considering whether it would be beneficial to communicate the results of a sensitivity analysis using tables. Returning to example 10.5, the information from the two-way sensitivity analysis would be most effective in a table due to the 9 possible combinations as shown in Figure 13.3 below.

		Units Sold		
		90	100	110
Variable Cost Per Unit	\$1.50	\$652.08	\$1,236.56	\$1,821.04
	\$2.00	\$457.25	\$1,020.08	\$1,582.91
	\$2.50	\$262.42	\$803.61	\$1,344.79

Figure 13.3:  
Communicating  
Results in a Table  
Format

Tables can also be used for best-worse case scenario analysis and other partial sensitivity analysis.

## Further Information and Real World Examples

For some example reports consider viewing the following links:

Example report on “Standing Council on Environment and Water” from PWC in 2011 which uses good practice for tables and figures [PWC Report, 2011](#)

Example report from Deloitte Access Economics titled “At what price? The economic, social and icon value of the Great Barrier Reef” which covers all important aspect of a CBA report including market and non-market aspects, and sensitivity analysis [Deloitte 2017](#)

For more information on different writing styles refer to the UQ assignment guide [Assignment types – my.UQ – University of Queensland](#)

## Summary of Learning Objectives

1. The goal of using reports for communicating analytical results is to communicate the information in a clear and precise manner to decision-makers and policymakers.
2. A CBA report should cover all 9 steps of a cost-benefit analysis whilst following a general report structure. Using headings, tables and graphs helps communicate the results of the CBA more effectively.

# ADDITIONAL MATERIALS





# APPENDIX: CASE STUDY

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## Worked Example – Solar Power Station

TurtleEnergy is considering a large-scale solar farm investment in Queensland. A solar farm (or solar power station) are large collections of photovoltaic (PV) solar panels that absorb energy from the sun to produce electricity. Solar farms are known as a good investment for firms who wish to reduce their carbon emissions as solar power generates significantly less carbon and invest in renewable energy. As TurtleEnergy is interested in sustainable investment, the company has asked for a social CBA on the potential project. However, TurtleEnergy is also interested in ensuring the investment is sound for their stakeholders. The company has provided the following information.

TurtleEnergy is expecting their solar farm to produce 110MWh. The project will last 20 years.

*[You can find the template Excel File on the BB website – this example is worked through during class]*

### a) Market Perspective

The project requires TurtleEnergy to purchase the following

- 430,000 solar panels at \$180 per panel. Each panel can generate 260w per hour.
- Racking and mounting frames: each rack is expected to hold 16 solar panels at a price of \$250 per rack.
- Two demountable building – one for storage and another for the control system. Each will cost \$63,000.
- Two transformers for the power to be converted for sale at a price of \$300,000.
- 110 centralised cable inverters at a price of \$450 each.
- Two worksite vehicles at a price of \$45,000.
- The company needs 100 small marshalling kiosks for the racks. Each kiosk costs \$250.

In addition to this, to build the solar farm there is a one-off pre-construction and transportation fee of \$3 million dollars. The project also requires a significant amount of cabling to connect the panels to the distribution. It was estimated that the project would need an initial 32,000 meters of cabling at a price of \$14.10 per meter. As part of the requirement to be a power generator, TurtleEnergy needs to purchase a turnkey protection and control system at a cost of \$1.5 million.

As part of the project, TurtleEnergy is expected to need to maintain and repair the solar power station if faults occur. To ensure timely repairing of faults, the company plans to keep working capital as outline in Table 1 below:

**Table 1: Working Capital**

Item	Units	Price Per Unit
Centralised Inverters	10	450.00
Spare Panels	64	180.00
Cabling	800	14.10
Spare Racks	2	250.00

In addition to the working capital, TurtleEnergy has provided the following information of their estimated operating costs:

**Table 2: Operating Expenses**

Item	Units	Price Per Unit
Land Lease (hectares)	250	3000
Grid Connection Fee	1	100,000
Spare Panels	50	180.00
Cabling	200	14.10
Monthly General Operating Expenses	12	2,100

Note that in an average year, TurtleEnergy expects to replace 50 solar panels (spare panels). However, TurtleEnergy wants to keep a stock of 64 spare panels in working capital in case of unexpected extreme events.

The farm required yearly checks and upkeep for monitoring equipment, expected to cost \$150,000 per year. The farm also requires an external yearly health and safety inspection to be conducted which comes at a cost of \$2,500.

In terms of workers, the project has operating expenses of:

- Two specialist maintenance and operational engineers who receive an annual salary of \$135,000.
- Additional casual maintenance and repair workers to keep the grounds and do general tasks – expected to cost \$200 per day for 70 days of the year.
- One site supervisor who receives \$175,000/per year.
- One external security operative to monitor the site at a cost of \$65,000 per year.

TurtleEnergy notes that the insurance would be 1.5% per annum of the initial fixed investment cost. At the end of the project, the farm will be dismantled and salvaged. This is expected to provide 5% of the initial fixed investment.

To calculate the income from the investment, TurtleEnergy determined that the site has an average of 8.2 hours of sun each day. 6.3 hours are at peak sun (100% energy production capacity) and 1.9 hours are non-peak (50% energy production capacity). We assume that the specified hours above consider days losses due to cloud cover.

Turtle energy expects to receive a minimum of \$44.50 per MWh when running at full power based on

the 2020 average market rate in Queensland. However, we require to take into account the peak and non-peak production hours over a day as part of the calculation of the total revenue benefits to Turtle Energy. Assume that the power station runs 365 days a year.

Finally, the project will be built in two stages. Stage 1 takes 2 years, consequently the solar farm can only operate at 50% total capacity in year 1 and 2. Stage 2 will be completed in 3 years and will result in the farm running at full capacity from year 3 onwards.

i) Calculate The IRR and NPV for the Market Perspective at a 5%, 10% and 15% real discount rate.

*Use a conversion factor of 1,000,000*

## b) Private Perspective

To finance the project and its high initial costs, TurtleEnergy would like to take a loan worth \$20 million at an interest rate of 5.4%. The life of the loan would be 15 years. In 2032, the company plans on taking a \$1 million interest only loan to cover any unexpected events. This loan has an interest rate of 9.5%. Over the period of this loan, only the interest is paid, at the end the loan is paid back in full in 6 years (at the end of 2038).

Depreciation for TurtleEnergy is complex. TurtleEnergy plans on depreciating the initial investment stock of solar panels purchased at the start of the project. However, the company will not depreciate any additional replacement panels purchased over the life of the project as the replacement panels are proportionally relatively small. The solar panels will be depreciated over the life of the project (20 years). In addition to the depreciation of the solar panels, the following assets can be depreciated over their book life

**Table 3: Assets for Depreciation**

Item	Life
Transformers	20
Demountable Buildings	5
Worksite Vehicles	6

The tax rate on profits is 30%.

i) Calculate the IRR on equity and NPV for the business at a 5%, 10% and 15% real discount rate for the Private/ Investor Perspective

## c) Social Perspective

You now need to consider the social perspective. The information on taxes and subsidies is outlined below and can be used to calculate the shadow prices.

**Table 4: Taxes, duties, and subsidies.**

Input Item	Information
<b>Duties:</b> – Demountable buildings	10%
– Transformers	15%
<b>Subsidies:</b> – Grid Connection Fee	80%
– Solar Panels	20%
– Protection and Control Syst.	10%
<b>Taxes :</b> – Vehicles	10%
– Monitoring Equipment	10%

As we observe taxes and subsidies only on inputs in this project, we assume that inputs represent additional quantities supplied (not diverted from other uses). Note that the government provides a 80% subsidy on the grid connection fee to encourage businesses to invest in renewable energy projects such as this one.

In addition to the taxes, duties, and subsidies we need to consider the role of labour inputs. Specifically, the maintenance engineers, and security workers are expected to be sourced from elsewhere. Casual employees have an opportunity cost of 40% of the market wage.

The opportunity cost of land is \$0.

Finally, you refer to some recent research and found that 1.60 units of carbon (CO<sub>2</sub>) are saved *per year per kWh* (1000 kWh = 1 MWh). Given that the site is expected to produce 110MWh, and the price of carbon is \$50 per tonne, you can calculate the net external benefit of the project by calculating the yearly savings.

- i) Calculate the NPV and IRR of the social perspective using a 5%, 10% and 15% discount

## d) Disaggregated Social Perspective

Now as part of the CBA, you would like to breakdown the benefits to various stakeholders for TurtleEnergy. In this analysis, you separate the benefits to the private investor (TurtleEnergy) from the benefits to society. In this case we consider those with standing including stakeholders (landowner, labour, banks, and government) to disaggregate and allocate the benefits to subgroups with standing in the project. Using the template identify:

- i) The NPV for the aggregate social perspective using a 5%, 10% and 15% discount rate (additional benefits that do not accrue to TurtleEnergy).
- ii) The NPV for each stakeholder group in the social perspective using a 5%, 10% and 15% discount rate.
- iii) The NPV for the private investor group using a 5%, 10% and 15% discount rate (the benefits to TurtleEnergy).

Once you have managed to complete these tasks you have successfully completed a full Social CBA!

## e) Sensitivity Analysis

Many of the inputs into the CBA provided by TurtleEnergy for the project are uncertain.

i) As part of the analysis, TurtleEnergy would like to know how variation between the price of electricity and the production of electricity will impact the IRR from the investor perspective. Allow the price of electricity to vary between \$34.50, \$44.50 and \$55.50 and the production in MWh between 100, 110 and 120. Determine whether the results will impact TurtleEnergy's decision to undertake the project.

ii) Suppose Turtle Energy would like to achieve a minimum IRR of 8% on the investment (as a hurdle rate). Using a threshold analysis, determine the required average price for electricity.

iii) Assuming the \$44.50 price of electricity from before. What is the minimum tax on profits that would result in the government breaking even at a 5% discount rate?

# ACKNOWLEDGEMENTS

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This interactive book is free for all to use to support the advancement of teaching and learning cost-benefit analysis, with a goal of inclusive education practice. Should you wish to provide feedback or comments please do not hesitate to contact me directly. My contact information can be found [here](#).